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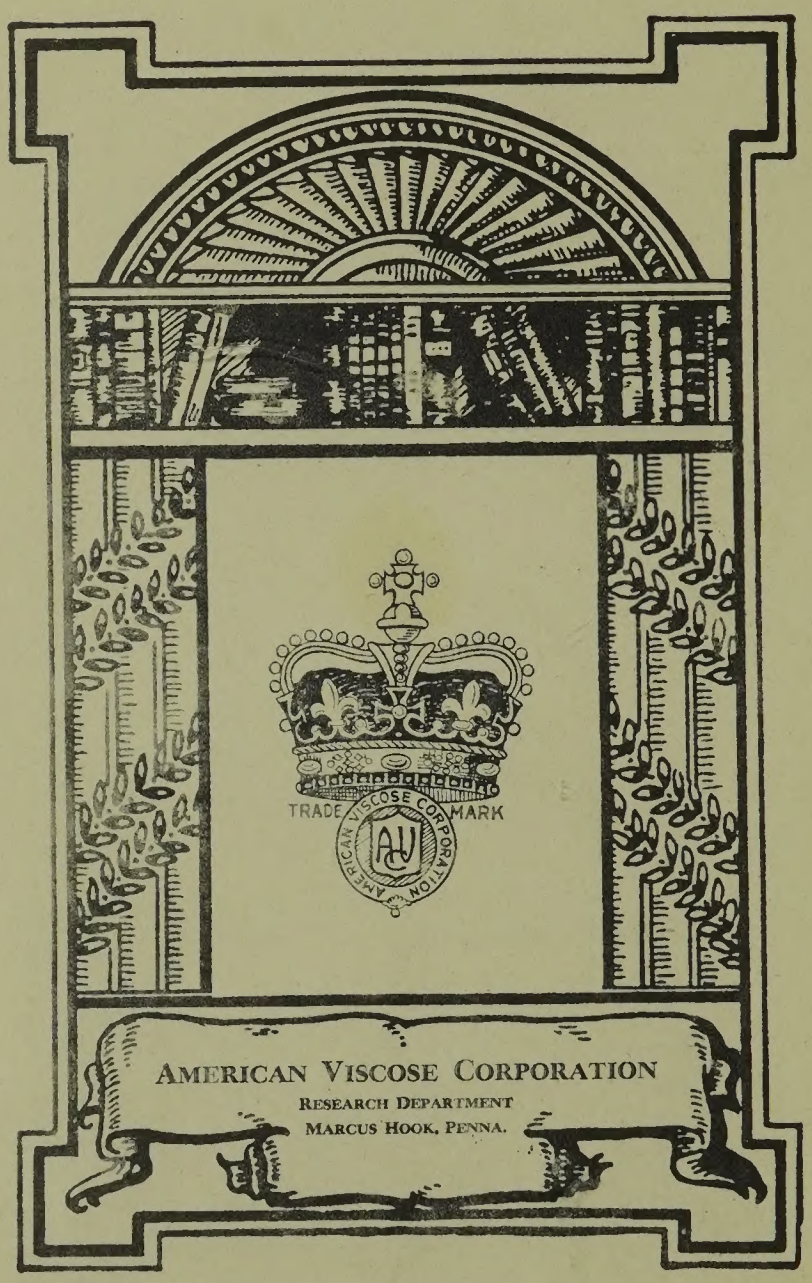

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TRANSACTIONS OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

EFFICIENCY IN CHEMICAL INDUSTRIES

THE CORN PRODUCTS INDUSTRY

By President T. B. WAGNER,

Read at the Boston Meeting, June 25, 1913.

During the Eighth International Congress of Applied Chemistry, held in New York in 1912, a number of general lectures were delivered, among them, one by Dr. Carl Duisberg of Germany, entitled, "The Latest Achievements and Problems of the Chemical Industry." With others, I was profoundly impressed with this recital of achievements—a splendid record indeed, bearing testimony to the distinguished services rendered by the Chemist and the Chemical Engineer. It is but fair that we give the latter full credit, for while the "pure" chemist takes the initiative by developing ingenious theories and syntheses, it is the chemical engineer who follows up the former's work and transforms it into commercial success, by which is judged, in no small degree, the value to mankind of scientific effort and accomplishments. Dr. Duisberg's essay surely brought to many of us the thrill of romance, but below it all lay a deeper meaning, for it spelled the "Triumph of Efficiency." We heard, among other things, what has been done in the way of producing cheaper power with engines driven by blast furnace gas, or Mond, or even peat gas; we were told of refrigeration, where, through the means of liquid air machines, temperatures were obtained as low as minus 190 degree C.; of rare metals and new alloys; of electrolytic iron and refined steel; of new methods of detinning waste tin; of the production of nitrogen

compounds from atmospheric nitrogen; of ammonia obtained direct from its constituent elements; of advancements in the manufacture of soda, chlorine and sulfuric acid; of the distillation of tar and of new coal tar products; of lake and coal tar colors; of synthetic perfumes and artificial silk; of pharmaceutical products and of chemotherapy; and lastly, of the brilliant results obtained in synthetical chemistry, especially in the syntheses of adrenalin and rubber.

Gentlemen, would not one have to be void of all sentiment not to be stirred when learning of such work, and not to take pride in being a member of so useful and illustrious a profession as that of Chemists and Chemical Engineers? We need not go abroad, however, to learn of the magnificent results accomplished by them, for we have abundant evidence in this country of the marvelous changes which their efficiency has brought about with the result that this country occupies to-day a commanding position among nations in the field of applied chemistry.

"Efficiency in Chemical Industries," the subject I have chosen for this occasion, leads one, as you have seen, into such vast fields of accomplishment and possibilities, that I fear my fate to-night might be that of the parson who arose before his congregation, and said: "My dear Brethren, I shall divide my sermon this morning into three parts—firstly, I shall announce my text; secondly, I shall depart from it; and thirdly, I shall never get back to it." To avoid such a calamity, the calamity of going astray, I shall speak to-day only on what efficiency has done for the industry with which I am identified—that of Corn Products. I trust I have walked in the highways and byways of that particular domain long enough not to get lost. A further reason why I have elected to speak on this subject is that experience tells me that we rather welcome an account of accomplishments in industries other than our own, for the precedent of another's difficulties encountered and overcome acts as a tonic to cheer us over the stumbling blocks in our own paths, but they are only stumbling blocks after we have passed them and left them well behind; when they loom before us, they seem to have the proportions of mountains!

The manufacture of corn products in this country is not an infant industry, and much has been written about it, its history and evolution. The first product manufactured from corn was starch, and the first manufacturer was Thomas Kingsford, his plant

being located at Oswego, N. Y. He commenced operations about 70 years ago, at a time when the raw material—Indian corn—was a low-priced commercial commodity, for in those years the population of this country was much smaller than to-day, home consumption was limited correspondingly, and a demand had not, as yet been developed abroad. The raw material was cheap, and the price of the finished product was high. The margin of profit, therefore, was considerable, and an attempt at efficiency did not appear imperative, particularly not since competitors were "few and far between." Thus the principal stimulus for efficiency was lacking. The almost exclusive aim—a commendable one—was to produce starch of the highest quality. The matter of yield and of cost was of secondary consideration. With good quality and rather handsome profits, why talk about economy or efficiency in the boiler house, in the engine room, in the transmission of power, or with respect to labor? Labor too was cheap in those days and labor unions were unknown. If the efficiency were to have been gauged, as it should among other things, by the recovery of products from a given unit, that is to say by the yield, it cannot be denied that a manufacturer could have taken but little pride in revealing his degree of efficiency. This should not be taken as a reflection upon the industry at that time, for to be fair, we must not judge conditions retrospectively. It was the status of the industry in those days, but that the future had many and far reaching changes in store soon became evident.

The price of corn gradually rose, and, due to growing competition, the price of the finished product declined, narrowing the margin of profit. The manufacturer, therefore, had to begin to pay attention to the subject of yield, and to an increase of revenue possibly by recovering some of those products which were allowed to run to waste. First among these were the nitrogenous ingredients of corn, the "Gluten," but the method of recovery was very crude. It was collected while in a wet condition, and its sale was in the nature of a local business, that is to say it was sold to the farmers located in the neighborhood of the factory, and used by them in feeding cattle. It was not known as a commercial commodity, yet the proceeds from its sale added materially to the reduction in the cost of starch. With an increased output, the local markets eventually proved too small, and it became necessary to recover the gluten in a condition which would permit

of shipping it to distant points. This led to drying the gluten, and while the recovery of this product in itself was a step in the direction of efficiency, the methods and appliances resorted to in drying were primitive. It did not take long, however, for efficiency to make its entrance; the apparatus first in use were capable of evaporating about 1000 pounds of water per hour; each unit of the apparatus employed to-day has an efficiency, expressed in terms of evaporation, equivalent to 9000 pounds of water per hour. The amount of dry gluten recovered in one of the larger factories is 250,000 pounds per day.

The hull of the corn, the "bran," underwent the same transformation and was changed from a waste product, or offal, to a valuable staple product, the amount recovered per bushel being approximately the same as that of the gluten.

In the course of time, the manufacture of glucose was started, and the enterprise flourished. The introduction of this new product from corn furnished a splendid opportunity for the display of efficiency. In a measure, the industry was an imported one, for glucose had been made from potatoes in Germany many years prior to the establishment of the first factory in this country. In those early days it was necessary not only to import the machinery, but skilled labor as well. Among the most important were the men in charge of the vacuum pans. They were brought here at the expense of the manufacturer and engaged at extravagant salaries. They were quick to realize their advantage, and soon became the "bosses" of the plant. They ruled absolutely. Their work was surrounded with great mystery, but it had to give way to efficiency, and to-day the position of a pan man is no more important than that of any other workman, in fact, unskilled men are often selected for this work and soon become experts at their posts. The problems which arose in the manufacture of glucose taxed the ingenuity and efficiency of the chemical engineer. To illustrate, I will cite the history of the Chicago Sugar Refining Company, which was organized by Chicago business men with a paid in capital of 1 ¼ million dollars—a large amount of money even in present-day enterprises, but particularly so in 1880, when this factory was constructed. Its purpose was the manufacture of anhydrous grape sugar (pure dextrose), the production of which, on a commercial scale, had been made possible by Dr. Arno Behr. His method differed from all previous ones in that alcohol was not required

in the process of crystallization. The price of sugar was high in those days; I believe it sold at 8 cents a pound. Anhydrous dextrose, or grape sugar, as it was called then, could be manufactured quite cheaply, as corn was still sold at a relatively low price. The scheme was to blend the soft cane sugar from Louisiana with this anhydrous dextrose, and sell the product to the confectioners, for whose purposes it was suited most admirably. The factory started off a great success. The product turned out was of the highest purity, and called forth the commendation of every one who tried it. Thousands of barrels were sent out in the course of a few months, but in the course of another few months, the shipments commenced to be returned to the factory, because it was found that the anhydrous sugar had absorbed the moisture contained in the soft sugars, with the result that the contents of the barrels had solidified into a hard mass. It was impossible for the confectioner to use this product, and the company stood face to face with the failure of an enterprise in which, by this time, approximately 1½ million dollars had been invested. There was no alternative but to shut down the factory. The question now arose what to do next.

Many suggestions were submitted, among them very worthy ones, but they were discarded until the chemical engineer stepped into the breach and suggested that this anhydrous sugar plant be converted into a glucose factory. I shall not go into details, but simply recite the fact that after untold efforts and untold moments of anxiety, the new venture succeeded, and in the course of time it prospered. It may be properly said that it was principally responsible for the development of the American Industry of Corn Products, as we know it to-day.

Even though it prospered, there were many problems. Every step in the manufacture of glucose requires the most careful attention, and chemical control is needed incessantly. The aim is first to obtain the raw material—starch—in as nearly chemically pure a state as possible; this means the elimination of all nitrogenous and fatty matter, a task which offers the greatest difficulties, because of the enormous scale on which the business is conducted, because of the condition of the raw material—whether fully matured or not, whether entirely sound or slightly deficient, and even because of atmospheric conditions which exercise a certain influence. The ambition of the manufacturer is water white, crystal clear glucose, which will retain its color in all seasons, in all climates,

and even if kept in transit or storage for a long period of time. Such quality depends upon a thousand and one factors, some of which it is very difficult to control. The refining of the glucose and the treatment of the refining agents are important problems, which, however, have been worked out most successfully, as the result of applied efficiency on the part of the chemical engineer.

The recovery of the gluten and the bran was an important step forward, but one of the most valuable parts of the corn was still allowed to go to waste, viz., the germ, which yields the oil. There was no incentive to recover it, since no one seemed to want the oil. Had it been produced on a large scale, there would not have been a market for it, although it was realized, even in those early days, that a vegetable oil of the character of that obtained from corn must eventually become a valuable article of commerce; so it did, but it took many years of hard work to bring about this condition. Shortly before I entered the business, less than 15 years ago they had just started producing corn oil on a large scale but had no market for it—the oil went begging; that was a serious condition. The Chicago factory produced at that time about 15,000 pounds of oil per day and selling as it did for less than 15 cents a gallon, the revenue from this production was but two hundred and fifty dollars. To-day the value of a gallon of corn oil is nearly 50 cents, and the amount of oil recovered from the same number of bushels as in the Chicago factory is worth $2,700. This is not due altogether to the increased selling price, but also to the greater efficiency prevailing in the separation of the germ, and the extraction of the oil resulting in a yield three times larger than in the days of the Chicago factory. To-day the gross value of the oil recovered from one bushel of corn, together with that of the oil cake obtained as a by-product, is equivalent to 25 per cent of the purchase price of the corn.

The ingenuity of the chemical engineer did not stop there. The price of glycerine was rising steadily, hence the proposition suggested itself of separating the glycerine from the fatty acids. What this meant is evidenced when I recite that glycerine to-day sells at 18 cents per pound and corn oil at about 6½ cents, and that 100 pounds of corn oil yield twelve pounds of glycerine; the price of crude oil and fatty acid is substantially the same.

To the list of by-products recovered, gluten, bran, oil cake, oil and derivatives, such as glycerine and fatty acids, another was soon

to be added. We still had a waste product, which, if recovered, seemed likely to be convertible into a revenue producer of the first magnitude. I am referring to the solids contained in the so-called "steep water," the water in which the corn is immersed and softened prior to grinding. It contains the most valuable ingredients of the grain, viz., the organic phosphorus compounds, magnesium and potash salts, nitrogenous bodies and sugars. Many efforts had been made to recover these solids in dry form, but owing to the hygroscopic condition of the residue, such methods were found to be impracticable. In some localities, serious consequences were the result. I have in mind the experience we had at an Iowa factory, grinding about 10,000 bushels of corn per day. The steep water was not recovered, but together with the wash waters from starch and gluten was run into a creek, which in turn, discharged into a river of fair size. This method of disposing of the steep water soon became a menace to the plant, for proceedings were instituted in the courts with a view to having the factory shut down and declared a public nuisance because the steep water contaminated the river, killing the fish and contributing in many ways to the discomfort of the residents. The owner of the factory being unable to satisfactorily dispose of this waste, as a last resort constructed a pipe line to a farm located about three miles from the factory and entered into an agreement with the owner of the farm whereby he was permitted to conduct the steep water through the pipe line from the factory to the farm and discharge it there. For that privilege, besides furnishing a most excellent fertilizing material, he had to pay the farmer three thousand dollars annually. To-day we recover this former waste, by collecting it, concentrating it *in vacuo,* and adding it to the gluten feed in the form of a syrup with which it is subsequently dried—the feed acting as an absorbent. Instead of investing in pipe lines and paying for dumping rights the waste of a 10,000 bushel plant was thereby converted into a revenue of almost $100,000 per year. Applied to the industry as a whole, this former waste furnishes to-day an annual gross income of approximately 1½ million dollars.

Very little is now running to waste. Whatever small loss there is, is caused by the soluble solids carried off in the water used in the washing of starch and gluten. However, these solutions of solubles being very dilute, it is doubtful whether an efficient method will ever be devised for their recovery at a profit. It will probably

be a question of economical evaporation, therefore, largely an engineering problem. Nor will the recovery of these solids add materially to the efficiency record in point of yield.

Efficiency has manifested itself in our industry in many ways. As production increased and finally exceeded the demand, ways and means had to be found for diverting the surplus into new channels. This meant partly new products and partly new markets. The latter were secured by entering our starches, for instance, into competition with products mostly foreign, such as rice, wheat, potato and cassava starch; and by studying closely the needs of the respective industries requiring starchy materials, we have succeeded, in a large measure, in replacing rice, etc., with products of corn.

The development of our products occurred simultaneously, and to the series of bulk products were added, in the course of time, a large number of special products, such as thin boiling and modified starches, suitable for every conceivable technical purpose, dextrines and gums, special varieties of glucose, mixed table syrups, so-called "70" and "80" sugars, and refined, hydrogenated and vulcanized corn oils. There is every prospect of further additions to the present number. Products of corn, in one form or another, are consumed to-day in almost every industry, and they reach every corner of the civilized world. Figuratively speaking, this branch of efficiency was raised from 1 to 100—that is to say, where originally the industry was based upon the manufacture of only one product, to wit, corn starch, to-day the number of separate articles obtained from corn presents the formidable array of 100 products and more.

Hardly anything, however, contributes so much to the general efficiency of an industry as the individual plant capacity. This is the part of our business which requires the special attention and skill of the engineer. It has been only ten years since we stopped operating those plants, having a unit of only 500 bushels of corn per day. Those plants could not compete with modern conditions for the simple reason that they did not keep pace with the demands of efficiency. How can a plant grinding 500 bushels of corn a day enter into competition with a plant converting into commercial commodities 30,000 bushels or even 50,000 bushels of corn, which is the daily capacity of the latest addition to our chain of factories, viz., the mammoth plant at Argo, Ill. It is the concentration of operations that makes it possible for this plant to carry off high-

est honors in point of efficiency, and this concentration is carried through every department of the plant, each department being organized as a manufacturing unit of its own. The boiler house is our steam factory. It is the business of the man in charge to manufacture and deliver steam at the lowest possible cost, and if you could go through this boiler house you would be surprised, perhaps, to find to what an extent chemical control is observed, and to what extent it contributes toward the low cost of steam. The efficiency of the boiler house depends, of course, not only upon its operation, but equally as much upon the equipment; hence the old tubular boilers had to give way to modern high efficiency water tube boilers. Where formerly the standard unit was 100 H. P., it is now 600 H. P. per boiler. We now have only mechanical stokers in place of hand-fired furnaces. Great savings have been brought about in coal and ash handling machinery, so that the operation of a boiler plant to-day requires but a fraction of the labor formerly employed.

Coincident with the increased efficiency of the boiler house was the rational, the scientific use of steam. Evaporation in driers and vacuum pans is done through exhaust rather than live steam, and one may well point with pride to the fact that in spite of the large amount of exhaust steam produced, our plants are operated without the discharge into the air of a single pound of unused exhaust steam.

The engine room is another such manufacturing unit, and a high degree of efficiency is required to produce and transmit motive power at a low cost. Here the slide valve engines had to yield to the Corliss type, and more latterly to the steam turbine. The costly transmission of power by belts, rope drives and transmission shafts had to give way to electrical power. Efficiency is carried into the minutest detail; even an item apparently so small as lubricating oil did not escape the general policy of efficiency; while such items do not represent an imposing saving per se, the aggregate foots up a substantial amount.

The milling department is another unit of its own and so is the refinery, the feed house, the oil plant, the dry starch house, the dextrine department, etc. Each one of these departments is in charge of a chief, responsible for the output, its quality and cost. This general efficiency is carried further in that we operate our own box and carton factories, our printing shops, barrel factories

and tin can plants, which latter have a record of efficiency second to none in this country.

You will have noticed that we distinguish between two domains of efficiency: first, that of the Manufacturing Department; second, that of the Engineering Department. In the latter may be included plant construction, for efficiency not only reigns on the inside, but makes itself felt on the outside as well. Improved plant construction leads to reduction of maintenance charges, to a lowering if not elimination of fire risks accompanied by a corresponding lowering of insurance rates, to a better safeguarding of the employees, to a reduction of accidents, and to an improved sanitary condition. The last-named features, in turn, lead to increased efficiency of the workmen, without which any attempt at a high degree of general efficiency must come to naught.

Another link in the chain of general efficiency is furnished by labor-saving devices, the result of which is that less men are employed to-day in a factory grinding 30,000 bushels than were formerly required to operate a plant with a capacity of only 10,000 bushels.

Gentlemen, I have singled out the industry of Corn Products because it furnishes one of the most striking examples of what efficiency has done for the development of a chemical industry within a comparatively brief space of time. Unlike other industries, such as steel or sugar, our industry is a conglomerate of a number of others. Per se, the manufacture of starch has nothing to do with that of oil; the manufacture of corn syrup nothing in common with the production of concentrated feeding stuffs; the manufacture of dextrines nothing with that of dextrose, etc., yet these various departments are so related to the whole as to form inseparable parts of it, and the efficiency of the whole depends, therefore, upon the efficiency of each branch.

The net result of our efforts with respect to efficiency is perhaps best illustrated by the fact that we pay to-day for our raw material—corn—three times as much as did our predecessors, and yet we sell our products in the markets of the world at one-third of their price.

To continue the increase of this efficiency, it is necessary that we have young men with the proper training—not only men with a scientific schooling, but men who have received thorough training in engineering, who know the parts and functions of machinery

and apparatus, who have a fair knowledge of factory operations, and who have a general understanding of the principles of manufacturing. It is gratifying to note that the number of colleges and universities is increasing from year to year, where a course of chemical engineering is added to the curriculum of the chemical student. The chemical industries of this country have grown from a small beginning into a position of great importance. A large share of the credit is due to the schools which furnished the men. They must give us men of ideas, men with initiative, men with mental and physical equipment to carry their creations of mind through into creations of fact. No matter how small a cog the individual may be in the big wheel of industry, he may well be proud of his share in the building up and development of the chemical industries, which contribute materially toward the prosperity of this country. If his work goes unnoticed by the public-at-large, he can find comfort in the fact that "The greatest joy of those who are steeped in work, and who have succeeded in finding new virtues and understanding the relations of things to each other, lies in work itself."

Such work cannot result other than in efficiency. Efficiency stands for all that is great and potential. Efficiency is the making of a man. Efficiency is the making of an industry. Efficiency is the making of a nation.

THE EFFECT OF LEGISLATION UPON CHEMICAL INDUSTRIES

By President T. B. WAGNER.

Read at the New York Meeting, December 10, 1913.

At the end of the eighteenth century an observation was made by Scheele in his laboratory, the results of which have meant more to the prosperity of all peoples inhabiting this planet than any other invention—chemical or otherwise. I am referring to the observation which disclosed the fact that cyanide of potassium is capable of dissolving gold. While this discovery was of much scientific interest at the time, and led Faraday to explain it by an elaborate theory, no industrial application was given to it until about one hundred years later. In April, 1890, the first plant operating under the McArthur-Forest method for treating ore tailings was started in Johannesburg. The effect of this process is reflected in a tremendous increase of the world's output of gold; consequently, the cyanide process plays an important part in the monetary system of the world, as the increased gold production effected by it has dispelled the fear that there might not be enough of the precious metal to maintain the gold standard of the civilized nations. The struggle in this country for the maintenance of the gold standard is within the memory of all, but I fear that, like in other instances, credit was not given to the chemist for his share in having the gold standard preserved.

The recital of this invention has no immediate bearing upon my subject, except in so far as it goes to prove that the furtherance of civilization and the furtherance of industries depend largely upon underlying conditions, which, in their incipiency, may seem trivial. That is the case with the effect of legislation upon the development of chemical industries. The chemical industries of the world are a little over one hundred years old, yet, in point of advancement and financial returns, their success is without a rival. Strange as it may seem, the starting of industrial enterprises is not always due to the

chase for the almighty dollar, as is generally and perhaps pardonably assumed, but in many instances it is directly caused by the enactment of laws with more or less restrictive tendencies. Let us go back to the birth of the chemical industries in the beginning of the last century. Napoleon the First, whose fame as a statesman and as a conqueror will shine like a beacon light as long as history shall be written, was at war with England. To crush his rival, this far-sighted statesman conceived the idea that the most effective way of accomplishing his purpose lay in the crippling of England's trade. The Continent naturally was the principal buyer of England's colonial products. Napoleon, therefore, in 1806, issued a ukase, according to which, England's colonial products were barred from the Continent, and all trade relations with England were forbidden; any country violating this ukase was apt to find itself involved in war with France. This ukase is known as Napoleon's "continental blockade." Among England's most important colonial products was cane sugar, but with the enforcement of the blockade the Continent found itself unable to obtain this sweetening agent, without which, life seem to be less sweet indeed. The price of sugar rose enormously and an impetus was thus given to the exploitation of the discovery of Margraf, made in 1747, that the ordinary garden beet root contained considerable quantities of sugar, identical with that found in the sugar cane. The first factory was built in Germany in 1801. Since then, this industry has had a marvelous growth, and the present production of sugar from this source exceeds that from cane. The world's production of sugar to-day is eighteen and one-half million tons, of which nine million tons are obtained from the sugar cane, and nine and one-half millions from the sugar beet. Of the latter only a little over 600,000 tons are produced in this country, the factories engaged in its manufacture numbering 72. Incidentally I might mention that while at the beginning of the industry about twenty tons of beets were required for the production of one ton of sugar the same amount of sugar is now obtained from only seven tons of beets. It is also worthy of mention that all of the potassium contained in the sugar beet and fully 65 per cent of their contents of nitrogen are recovered from the molasses and utilized over again. What effect the latest legislation, the new tariff, will have upon the industry in this country, whether it will prove that it has outgrown the state of an infant industry, or whether it still

requires the friendly and substantial support of a high protective tariff—that the future will demonstrate within a few years.

Coincident with the establishment of the beet sugar industry was that of another industry which was destined to play an important part in the economic conditions of this country and Germany, viz., the production of grape sugar from starch. The success of this new industry, it may be rightly assumed, is also attributable to Napoleon's exclusion of England's cane sugar from the Continent. The conversion of starch into a reducing sugar, by means of a dilute acid and heat, was discovered in 1811 by Kirchhoff, a teacher at the Imperial Academy of Sciences at St. Petersburg, and the first factory was built in Germany in the same year by the Grand Duke of Saxe-Weimar, at the instance of Professor Doebereiner of the University of Jena, whom you will remember as the inventor of the first "hydrogen lamp." Bearing in mind the present magnitude of this industry, it is interesting to read of the financing of this pioneer factory in Germany. I quote from a letter of the Grand Duke to Professor Doebereiner:

"The subscription is assured; my wife and I, my son and his wife are the four stockholders, each contributing one hundred taler. I shall advance the capital of four hundred taler, which is to bear interest at five per cent, and shall turn this over to you; you may then proceed immediately to start the plant. I shall deed my shares to you; I wish you every success and I am convinced that you will proceed carefully. As regards the concession I believe it can be arranged that it shall be granted for a period of years; however, it must not include the home production of syrup for home use. I intend coming to Jena this week; I shall then bring the money with me and we may discuss further details. I have looked up the manufacture of sulphuric acid in Chaptal & Klaproth. It seems to require a large capital, however, to build the lead chamber."

From this small beginning, the industry has grown into one of vast proportions, the yearly production in Germany being 120,000,000 pounds, and whereas, at the start, only grape sugar and syrup were produced, and the potato was the only form of raw material, at present by far the largest amount is produced from Indian corn and the number of different commercial commodities produced from the latter reaches almost one hundred. The industry consumes, in this country, about fifty million bushels of corn

annually, or practically one-sixth of all the corn which reaches the markets. These figures must not be interpreted as meaning a steady and unhampered growth of the industry. On the contrary, if all the legislation which was enacted had had the effect anticipated at the time of enactment, the industry would not have survived these attacks. For instance, in various States laws were passed putting glucose and grape sugar in the same category as poisons and prohibiting their use in food products. Only last year, attempts were made in the legislatures of two States to exclude glucose from use in confectionery, although it is conceded that its use results in a better grade of candy and that certain goods cannot be made without it; strenuous efforts were made by misinformed or biased persons to replace it altogether with invert syrup. Again, when it was discovered by Dr. Ludwig Gall that grape sugar lends itself admirably to the improving of wines, in which the amount of sugar produced by nature is deficient on account of adverse climatic conditions, this method of ameliorating wines, which has come to be known as "Gallizing," was hailed in Germany as one of the most important discoveries, affecting and improving the economic conditions of the provinces in which the wines were produced. Owing to the large demand which Dr. Gall's discovery created for this sugar, it contributed materially to the growth of the industry. Yet we find that only a few years ago conditions were reversed by legislative action and great restrictions were placed upon the use of this sugar in the amelioration of wines. In this country, the controversy over the use of sugar in wines, only a few months ago, almost caused the failure of the new tariff act. Our domestic wine industry is centered principally in the State of California on one side, and the States of Ohio and Missouri on the other. California produces grapes rich in sugar, whereas, even the best grapes produced in Ohio are deficient in sugar to such an extent as to produce a wine so low in alcohol as to be almost unmerchantable. The Ohio and Missouri wine producers, therefore, resorted to "Gallizing" ever since the industry was started in their States, about 60 years ago. Their ameliorated wines are said to be as good as any produced in California, yet the wine producers of that State tried to create the impression in Congress and elsewhere that California wines were the only pure wines, whereas, those produced in Ohio and Missouri were adulterated because of the addition of sugar. In

the production of sweet wines it becomes necessary to "fortify" the wines with brandy, and the California people succeeded in having an act passed by Congress in 1890, which permitted them to use brandy without paying the spirits tax of $1.10. It is said that since the passage of this act, the amount of money saved to the California interests was not less than sixty-three million dollars. To retaliate against California, the Ohio and Missouri interests appeared before Congress when the Underwood tariff bill was under consideration. One section of the tariff act deals with the income derived from internal revenue, and here the Eastern interests saw their opportunity and introduced a bill which would take from the California wine producers the privilege of using tax-free brandy. It would compel them to pay into the United States Treasury annually something like eight million dollars. The California interests answered in kind by introducing a bill, placing a tax of twenty-five cents per gallon upon all wines produced in the territory east of the Rocky Mountains, which, if enacted into law, would mean the annihilation of the industry in that territory. This, in turn, would injure the grape sugar industry, as it would curtail the consumption of grape sugar. Further consideration of the tariff bill came to a stand-still, as this so-called wine clause proved the stumbling block, and no headway was made until the entire wine clause was eliminated for the time being—Congress agreeing to give it its attention during the regular session.

I cite these cases to show the influence of legislation, even though indirect, upon the development of a chemical industry. What is one's loss is another's gain. For instance: the loss of the sugar business to England meant the birth of two important new industries and these in turn influenced the development of other branches of the chemical industries. It is but fair to state that the chemical industries in general owe a great deal to the beet sugar industry. Looking over the list of early chemists, and chemical engineers, who have distinguished themselves in the chemical industries, we find that most of them had their start in a beet sugar factory, likewise many successful works managers, for it was in this industry that the first complicated machinery was installed. The modern evaporating devices as well as the separation of solids from liquids by centrifugal force had their inception in beet sugar works.

I cannot leave this chapter without mentioning another instance bearing upon the beneficial, although unlooked for, results of restrictive legislation. A number of years ago a law was enacted in one of the wine producing countries abroad with reference to wines made from the residue of the pressings of the grapes, the so-called "pomace" wines. These wines were introduced by Pétiot, a French wine merchant, and were produced from Bordeaux wines by adding a sugar solution to the residue from the first must and fermenting a second time. The alcohol generated thereby dissolved coloring substances, as well as tannin and the flavoring principles, the "bouquet." This treatment is known as "Petiotizing" and is applied to Bordeaux wines four or five times in succession. Much sophistication was practiced—the pomace wines being sold frequently as natural wines. That government recognized the legitimacy of the "pomace" wine business, but it wanted these wines to be sold for what they were and did not want them sold to the public under a misleading name. The wines were supposed to be sold as "pomace wines," and to enable the government officers to distinguish them from "natural" wines, and to identify a pomace wine, the law provided that these wines must receive, before marketing, the addition of a small amount of phenolphthalein. The Inspector would examine the wines by adding a few drops of an alkaline solution which, of course, would turn the color red. If the color of a "natural" wine turned red, it was prima facie evidence that a pomace wine had been substituted. After this law had been in effect for about a year, it was observed that peasants living in the district where these pomace wines were produced, and consuming rather large quantities of these wines, developed what was then considered a disease and which assumed the proportions of an epidemic. The government dispatched its medical officers to make a thorough investigation, and subsequently they reported that they believed phenolpthalein to be the cause of the trouble. Thereupon clinical tests were instituted and the fact established that phenolpthalein was a most effective cathartic. While heretofore phenolpthalein was used primarily in the laboratories as an indicator, it now assumed an important position among our therapeutic chemicals and is at present manufactured in very large quantities.

Before leaving the subject of sugars, I must not omit a reference

to saccharine, a substance which has received extensive attention at the hand of legislative bodies. As you know, saccharine was discovered by Dr. Fahlberg, while taking a post graduate course with Prof. Ira Remsen at Johns Hopkins University. It was more or less an accidental discovery, as Dr. Fahlberg's work was in the direction of coal tar derivatives from a purely scientific point of view. The manufacture of this new sweetening agent was started in Germany and a new industry created which grew in importance so that it was eventually considered a menace to the beet sugar industry of the Continent. The latter, of course, is of greater importance to continental countries from an economic point of view, and the new rival of beet sugar was therefore discriminated against by laws which prohibited the use of this sweetening substance as a substitute for sugar, permitting its employment solely for medical purposes, the governments of Germany and Italy going so far as to prohibit the manufacture of the article itself. It was not prohibited because the article was injurious to health, but simply because of economic considerations. The importation into Germany being prohibited, it is interesting to note the accounts in the trade papers of the vast amount of smuggling from Switzerland into Germany. Incidentally this shows that notwithstanding the prohibition of saccharine in food a large demand for it still exists, and I am told that it is used chiefly in the households for sweetening jellies, jams, preserves and similar products in place of the expensive beet sugar, rather than by the manufacturers of such products. I read an account in one of the trade journals recently, according to which it was observed for some time by the customs authorities that an astoundingly large number of funeral parties crossed the Swiss frontier into the adjoining Grand Duchy of Baden —the explanation given being that the bodies were shipped into Germany in conformity with the wishes of the deceased to be buried in their native land. The number of funeral parties steadily growing in numbers, the customs authorities finally had their suspicions aroused and ordered a casket to be opened. It was discovered that in place of the supposed corpse, the casket was filled with packages of saccharine!

The most far-reaching legislation ever enacted was that directed against the discharge of sulphurous acid fumes from ore smelters. With the increased output of these smelters, the volume of

sulphurous acid discharged into the air became so large as to produce a most destructive effect upon vegetation. Laws were enacted in this country, as well as abroad, to the effect that unless the sulphurous acid fumes could be rendered harmless, the operation of these smelters would have to be stopped. The first attempts to convert them into a useful article were in the direction of compressing the gases into liquid sulphurous acid, which was used in the manufacture of glue and gelatine, but the amount of gas recovered from the furnaces grew so enormous that this outlet was not sufficient to take care of the supply. The attempts were then directed to oxidizing the sulphurous acid by means of the oxygen of the air for the production of sulphuric trioxide, following the re-action discovered by Clemens Winkler. These efforts proved extremely successful and works were soon established where SO_3 and finally sulphuric acid was generated from the waste sulphurous acid gases. In this manner a new process for manufacturing sulphuric acid was created, the so-called "Contact Process," which, in the course of time, thoroughly revolutionized a branch of chemical industry, in which the old established chamber process had come to be considered impossible of improvement.

I am particularly pleased to be able to refer in this connection to the splendid work of our fellow member, Mr. J. B. Francis Herreshoff, whose contact process has proven so superior to that of the Badische Anilin and Sodafabrik in point of economy and simplicity of operation that it is now being introduced into Germany.

The utilization of the waste gases from smelters had the effect of producing cheap sulphuric acid in localities where it would have been impossible to produce it by any other method. This had the most beneficial effect upon the development of the fertilizer industry in this country. Our Southern States, principally Florida and Tennessee, furnish to-day the bulk of the world's requirements of phosphatic rock. Liebig showed us how this insoluble phosphorus could be converted into a soluble form by a treatment with sulphuric acid, and for this purpose alone over three million tons of acid are used per annum.

The contact process, in turn, was responsible for the successful commercial production of synthetic indigo. The most successful method of producing it is a combination of methods suggested independently of each other, and consists in the following steps:

1. Napthalene to phthalic acid;
2. Phthalic acid anhydride to phthalic imide;
3. Phthalic imide to anthranilic acid;
4. Anthranilic acid to phenylglycin ortho carbonic acid;
5. Phenylglycin ortho carbonic acid to indigo.

The greatest problem was the production of phthalic acid. Heretofore it had been obtained through the oxidation of naphthalene by chromic acid. The latter, however, was very expensive and this method did not hold out much hope of commercial success. E. Sapper, a chemist engaged in experiments to reduce the cost of production of phthalic acid, conceived a new process of making it by heating naphthalene with highly concentrated fuming sulphuric acid. After years of experimenting, a suitable method was found, in the discovery of which accident, the patron saint of the inventor, played an important role. It was discovered that the addition of mercury to the solution of naphthalene in fuming sulphuric acid facilitated the re-action and resulted in an almost theoretical yield. We must bear in mind, however, that the commercial success of synthetic indigo was influenced, to a large extent, by the fact that the SO_2 generated by the process of heating naphthalene with sulphuric acid could be re-converted into SO_3 by the contact process. Even ten years ago one single establishment engaged in the manufacture of synthetic indigo re-converted into SO_3 forty thousand tons of sulphurous acid yer year, obtained in the manufacture of phthalic acid.

Thus we have seen that through the instrumentality of the law, a chemical process was introduced into metallurgical establishments, the contact process was created, a cheap supply of sulphuric acid was secured, which in turn, proved a blessing to agricultural interests through the production of a cheap fertilizing material, and finally it made possible the commercial exploitation of one of the finest achievements of scientific effort—the production of synthetic indigo.

Another impetus was given to chemical industries by laws aimed at stopping the contamination and pollution of rivers and other waters. Before the value of by-products was understood by manufacturers, the rivers and water-ways in general were used as the most convenient and inexpensive way of removing offal and waste of all kinds from the factory. It is not difficult to understand the results from such abuse of natural water courses. The com-

munities deriving their supply of drinking water from these sources were especially affected by it; the water, deprived of its natural content of oxygen, caused the death of the fish habitating in these waters and the odor produced by the decomposition of this offal brought much discomfort to the people living within the vicinity of such streams. It was a condition of which the legislatures were compelled to take cognizance, and the inevitable result was the prohibition of such use. This legislation proved disastrous to many industries but it proved of the greatest benefit to a far larger number. Among others, it affected beneficially all the industries connected with fermentation and those connected with the manufacture of starch from various raw materials. The materials recovered from the waste of these industries were converted into dry form, serving in most instances, for the feeding of cattle and live stock. Such feeds are those produced from the starch works, distilleries and breweries, and they rank among the most valuable concentrated feeding stuffs. They are indispensable for the rational feeding of live stock, which, together with wheat, form the principal means of sustenance of mankind. The production in this country of feed stuffs from the manufacture of starch alone amounts to over three hundred thousand tons per year, and since these feed stuffs sell at approximately twenty-five dollars a ton, the revenue obtained from this source amounts to seven and a half-million dollars per annum.

In former years, it was customary to allow the germs of the corn to go to waste, but to-day the industry recovers about seventy-five million pounds of oil per year, which is sold in the markets of the world at about four and one-half millon dollars. The corn solubles —the so-called steep water—are now recovered to the extent of one hundred million pounds a year, which are sold also in the world's markets at over one million dollars. The by-products recovered from distilleries and breweries in this country may be said to be worth about five million dollars per year.

One of the most prolific sourees of legislation is oleomargarine. Laws have been enacted in many States aimed at the destruction of this industry, as for instance the oleomargarine laws of Pennsylvania and New Hampshire, which required that no oleomargarine should be sold in those States unless it were colored pink. Yet, in spite of these restrictive, if not prohibitive, laws, this industry has

prospered, simply because of the underlying merit of the product itself. This is well illustrated by the fact that the receipts of the internal revenue office from the tax on oleomargarine amounted to $1,259,987.65 during the fiscal year ending June 30, 1913.

This subject furnishes a most interesting sidelight on the incongruities of laws. The artificial coloring of natural butter is permitted by a special act of Congress, even though the butter color used at the time of the enactment of this law would not be permitted to-day under the Federal Food and Drugs Act because of its injurious character.

The artificial coloring of oleomargarine, however, is not permitted, because such practice would make it an imitation of butter. If, however, the producer of oleomargarine is willing to pay a tax of 10 cents per pound, he then acquires the right to put his "fraudulent" product upon the market and the government becomes his silent partner. Most of the oleomargarine is produced by the packers, but it is only one of a large number of chemical products manufactured by them. It is only a relatively short time since chemistry has entered the packing houses and it was not entirely a matter of choice that led to the entry of the chemist, but rather stern necessity, for the law had served notice upon the packers that a stop would soon be put to their practice of discharging their enormous putrefactive wastes into creeks and rivers. This could not be accomplished without the aid of the chemist and the chemical engineer. As a result of their work, the packers produce to-day not only meats, meat extracts and soups, but they manufacture lard, tallow stearine and oleomargarine. They also produce soaps, candles and hydrogenated fats; in the manufacture of these products, they recover glycerin as a by-product. From the different parts of the animal, especially from the pancreas, the thyroid and the suprarenal glands, therapeutic agents of great medicinal value are obtained. From the stomachs of hogs pepsin is produced and the use of the latter has been greatly increased within recent years by the clever discovery of two brother chemists, the Messrs. Wallerstein of this city, that beer of absolute chill-proof quality is obtained by the use of pepsin. The governing thought of their invention lay in the desire to keep those albumenoid substances in colloidal solution which could not be separated during the process of refrigeration; the use of a minute quantity of pepsin makes this possible.

Further by-products of the packing houses are glue and gelatine, both products of great importance, particularly in view of the universal shortage all over the world of glue stock, and the correspondingly high prices prevailing for these products. The bones of the slaughtered animals are charred for the preparation of bone black, which as you know is a valuable filtering and refining material. In other departments of the packing plants brushes are made from the bristles of the hogs. The hair is also recovered and the skins and hides go to the tanneries to be converted into leather. What is left is placed on the market as fertilizing materials, as for instance, dried blood and tankage.

Viewing these remarkable results, it is obvious that there is hardly any necessity of further legislation for the disposition of offal from the packing plants.

Other industries directly affected by legislation prohibiting the pollution of streams are the paper and pulp industries. Here, however, the problem of a satisfactory disposition of the objectionable materials offers greater difficulties than in most of the other industries. Some of the waste material is recovered through mechanical separators, but most of its still goes to waste, and this has resulted in the closing by law of a number of plants. A beginning towards recovery has been made through the Mueller-Kestner process whereby the spent sulfite liquors are neutralized and then concentrated in a vacuum system. The liquid thus obtained is used principally for laying dust on roads in the same manner as petroleum oils are used in this country. In Sweden attempts are being made to produce ethyl alcohol from sulfite liquors and the results are claimed to be quite satisfactory, but while these are steps in the right direction, the great problem affecting these industries still remains unsolved. In this connection, I do not think it amiss to point out another incongruity of laws as enforced in various countries and the discrimination shown against certain products. One of the greatest wastes in this country is that of the lumber industry. The waste in that particular industry is appalling and when we recall the strenuous efforts toward conservation of our natural resources, one stands aghast at the wanton waste still going on in that industry, for wherever you see a lumber mill of large capacity, you will invariably find a burner installed where such wood waste as cannot be used in the production of steam is incinerated,

and millions of dollars' worth of material escapes unused into the air in the form of gases. During the last few years an industry has been started in this country based upon the observation that cellulosic materials can be converted into reducing sugars, from which ethyl alcohol may be produced. Only two plants are in operation thus far, but the results obtained seem to indicate that this new method of producing ethyl alcohol is commercially feasible and lucrative. The cash capital invested in these plants amounts to one million dollars. The product obtained is of the very highest grade, practically free from fusel oils and surpassing that produced in grain distilleries, yet the most natural outlet for ethyl alcohol is closed to this industry, because our laws provide that only grain distilled spirits may be used in the compounding of whiskeys. In Canada, however, no such restrictive legislation exists because there the law simply provides that ethyl alcohol may be used irrespective of its source. It would not be surprising, therefore, if the development of this new industry would prove speedier in Canada than in this country.

Of much interest to chemists is a bill recently introduced in Congress by Representative Falson of North Carolina, providing for an appropriation of $400,000 to enable the Department of Agriculture to procure economical methods for the production of artificial fertilizers by means of electricity. It would seem that official circles have taken cognizance of the fact that the saltpetre deposits in Chile are not far from complete exhaustion, and that our lawmakers have arrived at the conclusion that they can rely upon the chemist to meet the situation—producing a cheap nitrogenous fertilizing material in place of saltpetre, which can be secured in unlimited quantities.

You all know that the utilization of nitrogen from the air by the combination of nitrogen and oxygen of the atmosphere with the formation of nitric acid is an accomplished fact, that is brought about either through the medium of the electric arc and the silent electric discharge, or under the influence of high electric tension. In the form of a new chemical compound, called Calcium Cyanamide, which is produced by combining nitrogen from the air with calcium carbide, a plant food is obtained which, as a fertilizing agent, is as efficient as Chile saltpetre or ammonium sulphate. The production of these substances from atmospheric nitrogen

will therefore remove the anxiety of many writers on economics concerning the difficulty of feeding an ever increasing population, owing to the gradual exhaustion of the soil.

Since nitric acid is also used largely for nitrating glycerin, cotton and cellulose, and since these nitrated products are the principal constituents of the smokeless powder and high explosives used by the armies and navies of the world, it is apparent that aside from its importance from economic considerations, a process of making nitric acid independently of Chile saltpetre will become of extreme importance in case of war, for it removes the danger of being cut off from the supply of Chile saltpetre by a hostile navy.

As yet, the principal production of nitric acid from atmospheric nitrogen is centered in Norway, because that country has natural water power of a tremendous magnitude, with the further advantage of being located within easy reach of the principal markets abroad. Even in Norway, however, restrictions have been placed by law upon this new industry—the law providing in effect that only citizens of Norway may be engaged in the exploitation of these natural water powers. This caused the severance from the Norway enterprise of Dr. Schoenherr, one of the pioneers of this new industry.

The time at my disposal does not permit of enumerating all that has been accomplished in the utilization of industrial wastes through the compelling force of legislation. The aniline industry, the production of sulphate of ammonia from gas residues, of copperas from pickling liquors in steel and wire works, of copper zinc and nickel from plating works, of fats and soaps from textile mills, and the products obtained in the reduction of garbage would all come under this heading. The last named subject alone is not only of the greatest importance and greatest interest, but in itself would suffice for a complete address. It is our fortune to have been able to make an arrangement, largely through the co-operation of our fellow member, Dr. Maximilian Toch, to visit the garbage reduction plant on Barren Island, a courtesy which I understand has not been enjoyed by any other scientific or technical association. What I might say on the subject of garbage reduction, I am sure, will be said in a much more comprehensive manner at the time of our visit to Barren Island, so that I believe I have your permission to leave the subject for the time being.

I believe I have shown that what may at first have seemed

oppressive legislation actually developed into progressive legislation, and led to the building up of important chemical industries, which, in point of commercial value, as well as in point of direct benefit to mankind, rank second to none. And now when fears are expressed regarding the commercial and industrial future of this country because of the present tendency to disband large industrial organizations and corporations, I believe the chemist has no cause for apprehension, for it is the chemist, first of all, who is sought in times of need. His services are appreciated all the more when competition calls for a greater exercise of scientific knowledge and of technical skill. This holds good even with respect to the effects of the new tariff. While the removal of a high protective tariff may bring hardships to certain industries, the ingenuity of the chemist and chemical engineer will assert itself and lead us to conditions possibly more equitable than they have been in the past. I believe that it will always be a case of history repeating itself, and I cannot see other than a most hopeful future for the chemical industries of this country.

THE DISTRIBUTION OF HEAT IN THE OPERATION OF STEAM BOILERS

By PERRY BARKER.*

Read at the Boston Meeting, June 25, 1913.

In the process of combustion of coal in boiler furnaces a comparatively large percentage of the heat in the fuel is not usefully employed for the generation of steam. The extent of the losses which ultimately affect the boiler efficiency is governed by (*a*) the design and physical condition of the plant, (*b*) the personal element in the operation of the boilers and furnaces, (*c*) the character and adaptability of the fuel for the plant in question and (*d*) the rate of steam generation or capacity at which the boiler is operated. The efficiency with which fuel is burned is controlled by these factors and excessive losses may be due to one or a combination of the contributing causes.

In accordance with the recent recommendations of the Power Tests Committee of the American Society of Mechanical Engineers, a balance accounting for the distribution of heat in a pound of dry coal fired consists of the following items:

1. Heat absorbed by the boiler.
2. Loss due to evaporating and superheating moisture in coal.
3. Loss due to evaporating and superheating moisture formed by the combustion of hydrogen and distillation of oxygen-hydrogen compounds in the coal.
4. Loss due to heat carried away by dry flue gases leaving the boiler.
5. Loss due to heat escaping through the formation of carbon monoxide (CO).
6. Loss due to combustible removed from ash pits and from grates during cleaning.

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7. Loss due to superheating moisture in the air used for combustion.

8. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for.

Of the items enumerated above, (4), (5), and (6) generally constitute about 75 per cent of the total heat which is lost in the operation of steam boilers and are the variable factors which have a direct effect on the percentage of heat imparted to the water in the generation of steam. In presenting certain data on these losses, illustrations of the origin, extent and methods which have been employed for their reduction, are submitted.

The loss which is generally the largest and in the majority of cases most easily reduced is the heat carried away by the dry flue gases escaping from the boiler. Under this heading are included the sensible heat in the carbon dioxide and carbon monoxide, if any, formed by the combustion of the carbon in the fuel and the heat in the air in excess of that theoretically required leaving the boiler at the temperature of the escaping gases.

The principal causes of this loss are as follows:

(*a*) Improper methods of firing, which allow large quantities of air to enter the furnace either through the grates or fire doors.

(*b*) Condition of boiler settings. If the settings are cracked and the iron work is badly warped, a large amount of air is drawn through any openings, thereby reducing the draft available at the grate, diluting and cooling the gases as they pass over the heating surface.

(*c*) Poor quality of coal. Coals which contain a high percentage of ash or have a tendency to clinker cause an uneven distribution of the air through the fuel bed. When such a condition exists, large volumes of excess air enter the furnace and carry away heat in the flue gases. If the fuel is particularly fine, it will pack on the grate and produce an effect similar to that noted above.

This loss depends upon the weight of gases per pound of carbon burned together with the temperature at which these gases leave the boiler. The data which are required for this computation are the temperature of the flue gases, temperature of the boiler room, composition of the flue gases, the heating value of the coal and the carbon content of the fuel and ash pit refuse.

Several tests conducted in a plant in which the loss of heat

in the flue gases was originally high are submitted in Table No. I. The plant in question consisted of hand fired horizontal return tubular boilers equipped with plain grates upon which Pennsylvania semi-bituminous coal containing about 9 per cent of ash and 22 per cent of volatile matter was burned. The fires in this plant were carried at a thickness not exceeding 7 inches and were uneven, thereby permitting a very large air excess. The thickness of the fire was increased and the methods of firing were altered which resulted in a reduction of the loss of heat due to the enormous air excess from 36 to 12 per cent, with a resultant increase of about 20 per cent in the boiler efficiency. These tests afford conclusive evidence that the air excess maintained throughout the latter tests was somewhat lower than could be recommended for regular operation, as it will be observed that considerable carbon monoxide was formed under the existing conditions of air supply.

TABLE I

PLANT SHOWING EXCESSIVE LOSS DUE TO HEAT CARRIED AWAY BY DRY FLUE GASES LEAVING THE BOILER

	Original Conditions.	Tests to Effect Improvement in Efficiency.	
1. Loss due to heat carried away by the dry flue gases	35.9	10.0	12.4
2. Loss due to evaporating and superheating moisture in coal and moisture formed by the combustion of hydrogen and distillation of oxy-hydrogen compounds	2.7	2.7	2.8
3. Loss due to heat escaping through the formation of carbon monoxide	0.0	0.4	1.6
4. Loss due to combustible removed from the ash pits and from the grate during cleaning	3.2	7.6	4.5
Total determined losses	41.8	20.7	21.3
5. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for (assumed constant for all tests)	8.9	8.9	8.9
6. Approximate percentage of heat absorbed by the boiler or boiler efficiency (by difference)	49.3	70.4	69.8
Total	100.0	100.0	100.0

The loss of heat due to the incomplete combustion of carbon to carbon monoxide is usually an important factor in studying and

perfecting the process of combustion. Carbon monoxide occurs in flue gases generally accompanied by tar vapors or particles of solid carbon in the form of smoke, together with small percentages of unburned hydrogen and hydrocarbon gases. The formation of carbon monoxide is due to the following causes:

(*a*) Furnaces of poor design.
(*b*) Improper methods of firing.
(*c*) The character of the fuel, particularly with reference to the equipment in which it is burned.

While the presence of carbon monoxide (CO) shows that some heat is lost through incomplete combustion, a small percentage of this constituent generally indicates that the air excess is reduced as low as practicable. A small amount of smoke, as evidence of the presence of carbon monoxide, is a more convincing indication of economical furnace operation than a smokeless stack which may be emitting several hundred per cent of excess air.

The extent of this loss is dependent upon the percentage of carbon monoxide (CO) and carbon dioxide (CO_2) as determined by the flue gas analysis, the heating value of the coal and the percentage of carbon in the coal fired and in the ash pit refuse.

The results of several tests in a plant where loss due to unburned gases, as indicated by the presence of carbon monoxide (CO), was particularly high, are shown in Table II. The boiler equipment consisted of hand-fired vertical tubular boilers equipped with shaking grates. Coal from the Georges Creek field containing approximately 18 per cent of volatile matter was burned. The high loss due to incomplete combustion was not attributed to the character of the coal, although it had been proved that the furnace space in the boilers was not sufficient to burn coals containing higher percentages of volatile matter without the production of excessive amounts of smoke, indicating a large loss due to incomplete combustion. A side from the question of furnace design, the primary cause of the high percentages of carbon monoxide (CO) was the thickness of the fires. By reducing the thickness from 30 inches to 12 inches and changing the manner in which the coal was fired, the loss due to this factor was reduced from 14 to 1 per cent, with a corresponding increase in boiler efficiency.

TABLE II

PLANT SHOWING EXCESSIVE LOSS DUE TO HEAT ESCAPING THROUGH THE FORMATION OF CARBON MONOXIDE (CO)

	Original Conditions.	Tests to Effect Improvement in Efficiency.	
1. Loss due to heat excaping through the formation of carbon monoxide (CO).....	15.3	1.1	2.1
2. Loss due to evaporating and superheating moisture in coal and moisture formed by the combustion of hydrogen and distillation of oxyhydrogen compounds.....	4.1	3.8	4.2
3. Loss due to heat carried away by the dry flue gases.....	9.7	15.1	10.7
4. Loss due to combustible removed from the ash pits and from the grate during cleaning..	3.2	3.5	3.3
Total determined losses.....	32.3	23.5	20.3
5. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for (assumed constant for all tests).....	11.2	11.2	11.2
6. Approximate percentage of heat absorbed by the boiler or boiler efficiency (by difference)....	56.5	65.3	68.5
Total.....	100.0	100.0	100.0

In the operation of a boiler plant a certain percentage of the fuel which is fed to the furnace drops through the grate and is removed from the ash pit. An additional quantity of unburned coal is drawn from the grates in hand-fired plants when the fires are cleaned. The amount of fuel lost in this manner depends on:

(*a*) The character of the coal.
(*b*) The condition of the equipment.
(*c*) The methods employed in handling the fires.

If the coal is fine or non-caking and the grates contain large air spaces, excessive amounts of fuel drop into the ash pits. Certain coals clinker badly under some conditions of operation and, therefore, during the removal of this clinker excessive amounts of unburned coal are drawn from the fires. Another cause of this loss is the frequent barring or raking of the fires when a fine or non-caking coal is used.

The ash pit loss which also includes the combustible removed during cleaning is determined from the weight of this material,

the percentage of combustible which it contains together with the weight of the dry coal fired. For the purpose of this computation the heating value of the combustible is taken as 14,600 B. t. u. per pound. In special cases where complete boiler tests are not made and the weights of coal and ash pit refuse are not obtained, the percentage of the heat in the fuel removed with the ash pit refuse and cleanings can be computed from the analysis of this material and the determination of the prcentage of ash in the coal as fired. In calculating this item by the latter method the assumption must be made that the percentage of ash obtained by the proximate analysis of the fuel represents the inert matter in the ash and refuse removed from the ash pit and the furnaces; that is, no account is taken of the ash which is carried off the grates and deposited in the combustion chamber, upon the water heating surface or lost up the stack. A series of tests which indicate the extent to which this loss can be reduced are submitted in Table III. This plant was equipped with inclined grate stokers upon which Pittsburg slack coal was burned. The excessive rate at which the fuel was burned in order to maintain the required capacity caused deterioration of the grates, which allowed large amounts of unburned coal to fall into the ash pits. By careful attention to grate repairs and methods of operating the stokers the boiler efficiency was increased approximately 10 per cent.

The percentage of hydrogen in various coals is not an indication of their relative value when burned for the generation of steam. The essential feature in determining the effect of this constituent in the process of combustion is the form in which it is available in the furnace. Hydrogen which is driven off in the uncombined state and burned by mixing with the oxygen from the air supply is a valuable factor in the process of combustion as it develops about four times the heat generated by an equal percentage of carbon. However, a certain percentage of the hydrogen in coal is distilled from the bituminous matter in the form of tar vapor and water. The nature of these compounds has been ascertained when coal is subjected to destructive distillation, as in the manufacture of illuminating gas, but the transformations through which this portion of the hydrogen passes in the boiler furnace is as yet undetermined. For the purpose of this discussion the theory of the code of the American Society

of Mechanical Engineers for conducting steam boiler trials, for the loss due to hydrogen, is accepted. This theory assumes that all hydrogen contained in the fuel, together with an equivalent amount of oxygen in the form of water is raised from boiler room temperature, evaporated in the furnace and is eventually superheated to the temperature of the escaping gases. The amount of heat lost in this manner depends upon the composition of the fuel, the temperature of the boiler room and the temperature of the escaping gases. In addition to the loss due to evaporating and superheating the moisture formed by the combustion of hydrogen and by the distillation of oxyhydrogen compounds, a small loss is incurred by subjecting the moisture in the fuel and in the air used for combustion to these processes.

TABLE III

PLANT SHOWING EXCESSIVE LOSS DUE TO COMBUSTIBLE REMOVED FROM ASH PITS AND FROM GRATES DURING CLEANING

	Original Conditions.	Tests to Effect Improvement in Efficiency.	
1. Loss due to combustible removed from the ash pits and from the grate during cleaning..	13.1	9.1	7.9
2. Loss due to evaporating and superheating moisture in coal and moisture formed by the combustion of hydrogen and distillation of oxyhydrogen compounds.....	3.2	3.3	3.4
3. Loss due to heat carried away by the dry flue gases.....	22.8	19.1	18.2
4. Loss due to heat escaping through the formation of carbon monoxide.....	0.0	0.0	0.0
Total determined losses.....	39.1	31.5	29.5
5. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for (assumed constant for all tests).....	7.5	7.5	7.5
6. Approximate percentage of heat absorbed by the boiler or boiler efficiency (by difference)..	53.4	61.0	63.0
Total.....	100.0	100.0	100.0

Increasing interest in the economical operation of boiler plants has resulted in marked improvement in efficiency in the majority of the plants where this matter has been given careful attention.

An illustration of the distribution of heat in a boiler plant which was operating with high efficiency before tests were made for contemplated improvement is shown in Table IV. This plant consisted of large units of Climax water tube boilers equipped with circular grates which were fired through a number of doors. It will be noted from the tabulation that considerable loss due to the formation of carbon monoxide (CO) occurred but this waste is more than counterbalanced by the particularly small percentage of combustible removed from the ash pits and furnaces. The amount of combustible in this material averaged about 12 to 15 per cent, representing a fuel loss of from 0.5 to 1.0 per cent. Although the operating conditions in this plant were excellent, still greater care in the methods of firing effected an increase in boiler efficiency.

TABLE IV

PLANT OPERATING WITH HIGH EFFICIENCY

	Original Conditions.	Test to Effect Improvement in Efficiency.	
1. Loss due to evaporating and superheating moisture in coal and moisture formed by the combustion of hydrogen and distillation of oxyhydrogen compounds	4.0	3.8	3.8
2. Loss due to heat carried away by the dry flue gases	14.4	10.1	11.8
3. Loss due to heat escaping through the formation of carbon monoxide	0.9	1.3	0.4
4. Loss due to combustible removed from the ash pits and from the grate during cleaning	0.6	0.8	0.9
Total determined losses	19.9	16.0	16.9
5. Loss due to unconsumed hydrogen and hydrocarbons, to radiation and unaccounted for (assumed constant for all tests)	8.0	8.0	8.0
6. Approximate percentage of heat absorbed by the boiler or boiler efficiency (by difference)	72.1	76.0	75.1
Total	100.0	100.0	100.0

The object of this article has been to indicate in a general way the problems which are encountered in determining the distribution of heat in the operation of a boiler plant. A study of the controllable losses, giving particular attention to the personal ele-

ment, design and character of the equipment and quality of the fuel by the application of the principles of engineering and chemistry, can undoubtedly reduce them and effect a marked increase in efficiency.

DISCUSSION

Dr. WAGNER: "I think we all agree that the work presented by Mr. Barker's paper is of the most important kind, and it is a work that has presented itself only within a period of comparatively recent years, and I do not think it is more important in any department of manufacture than in the boiler house, and I think if Mr. Barker can spare the time we would like to submit a suggestion that he compile and reproduce it in the form of a treatise as represented in dollars and cents."

Mr. BOOTH: "I have one case in mind where the loss had been great. I suggested tearing the plant down, and when they got as far as knocking a hole in the wall, they found that conditions were much improved, as there was a better draft, and the plant is doing finely now."

It was stated that it was surprising how many plants throughout the country were not giving due attention to the controllable heat losses in the plants.

In reply to a question in regard to the composition of the coal used in the plant referred to, which was equipped with 1000 horse power Climax boilers, Mr. Barker gave the following data:

Volatile Matter	15.00 to 16.00%
Ash	6.00%
Sulphur	1.25%
B. t. u. per pound (dry basis)	14,800

GENERAL EFFICIENCY IN DYEHOUSES AND BLEACH WORKS

By LOUIS JOSEPH MATOS

Read at the Boston Meeting, June 25, 1913.

It has well been stated that the enemy of waste is efficiency, whether of labor or machinery. If the kind and character of labor engaged in any work are of the highest order commensurate with the character of output, just so high will be its value, and likewise, if the tools and appliances made use of in forwarding the raw material from one process to another are of the highest possible type suited to the purpose, so again will the condition and quality of the output be high in proportion.

Perhaps in no industry is the force of the above statements more apparent than in the conversion of raw textiles into finished fabrics, whether they be cotton, wool or silk, and in no sub-division of these industries more so than in the dyehouses and bleaching plants. Other departments of textile mills contribute their share of skill to the value of the ultimate fabric, notably the finishing department, which has more to do in the physical handling of the goods than other departments, and consequently its treatment may be safely omitted at this time.

The dyehouse of a modern textile mill is in reality a huge laboratory where the raw stock, yarn or piece goods of whatever fiber made is colored to meet certain commercial demands. It is in this laboratory that the material to be dyed is generally prepared for the actual dyeing operation by such treatments as will better enable it to take the mordants or dyes, as the case may be. This preparatory treatment consists in the majority of instances in cleaning or scouring the goods free from all extraneous oils, grease, dirt, etc., that become attached to it unavoidably in its passage through the mill, or which may have been added to it intentionally, such as oils in the case of wool. Consequently it

stands to reason that if the dyer is expected to turn out good work it means that the goods delivered to him should be clean; that is, thoroughly scoured out, or boiled out, with either soap or soda according to the stock, and then finally rinsed. Here the lack of efficiency in many woolen mills is painfully apparent; through misdirection or otherwise scouring in alkaline soap liquors is pushed to the limit under the mistaken idea that hard punishment of the pieces is the best means of removing oils and dirt; this is followed by failure to give the best part of the scouring—the final ample washing in water, so ample as to remove all traces of the emulsified oils and the emulsifying soap liquors. Absolutely false economy is experienced by such treatment of woolen or worsted goods, for the reason that traces of soapy liquors remaining are the unmistakable causes of so-called cloudy or streaky goods; defects that cannot be removed and can only be hidden by over-dyeing with other and heavier shades or by stripping and re-dyeing. Two definite results are then obtained: (1) The goods are not of a level shade, and consequently, if otherwise acceptable, must be sold at a lower price than they would normally command; (2) If they are stripped and re-dyed, other conditions of feel, handle, texture and shade being equal, the time and the cost in re-handling and re-dyeing are absolutely lost, and cannot be recovered from the buyer.

Efficiency in the preparatory treatment of woolen fabrics therefore resolves itself into thorough scouring and perfect rinsing, without which no piece of goods is ready to be dyed. Perfect scouring, again, brings pointedly before us the necessity of having good water to scour with. Some mills are so favorably situated that their water supply is of very low hardness and generally free from suspended matter, but, on the other hand there are many mills that have only a moderately soft water and some where it is liable to be contaminated with much silt. Where the water is clear and soft, or moderately so, no bad effects are to be found in the goods due to the water, but under the mistaken idea that cheapness is an element of economy, some mills having an unlimited supply of good water use mill soaps of the lowest grade, rosin filled, with the result that the characteristic odor of rosin persistently remains with the goods, whereas if even a fair quantity of tallow soap had been used, the goods would at least be free from odor if well rinsed.

The importance of water softening in connection with dye and bleach works has not reached the position it deserves, but as competi-

tion increases among textile mills, and the demands for relatively better fabrics from a constantly discriminating public increase, the mill that aims to meet these particular demands will be the mill to avail itself of every scientific help. It is a fact that there are to-day otherwise practical mill men who conscientiously believe that the tenaciously adhering lime soaps, the result of hard water, are effectively removed in a competitor's mill and regard with sincere distrust the statements of chemists that such deposits when formed on wool are irremovable when such deposits are found on woolen goods in their own mill. Irrespective of the saving in the cost of soap which could be credited to increased scouring efficiency, the amount so saved would in many mills be the interest on the money invested in an effective water softening plant.

Modern ideas in textile machinery have in general kept pace with other improvements, but there are many large mills that years ago turned out goods that held a prominent place in the market, but now these do not meet with the same favor as goods from other mills. On examining the cause of this condition, we are confronted with the fact that the machines used are of types long since discredited and abandoned. This applies to scouring as well as to dyeing. The old type of woolen goods washers, found in many mills, depended upon their harsh and energetic treatment of the cloth itself, leaving the solvent and detergent action of the soap and alkalies used to take care of themselves, whereas the more advanced type of appliances is so constructed as to give the soapy liquors the very freest action, without in the least impairing the condition of the cloth. Scouring of woolen goods is essentially a chemical process and not a mechanical operation.

Economy in the dyehouse proper may be effected along various lines, but each should be so considered that it fits in perfect accord with all other lines, so that there may be a maximum output of clean dyed goods ready for the dry-room or finishing department.

Dyehouses in which the labor, that is, the so-called kettle hands are not identified with their work, can never work as smoothly as those where the workmen are made to feel that they are a part of their department. Perhaps in no other department of a mill is the personal equation so much in evidence as in the dyehouse, and it should be the one where there is the least discord.

It was formerly the case that the master or "boss dyer" struggled under great difficulty to acquire his fund of information,

and this he, perhaps with good foresight and intention, preserved with great care to himself. He was on close personal terms of intimacy with his several helpers, the most ambitious of whom, ultimately and in turn became a "second hand," and was taught the principles of the trade, which in reality were the names of the "drugs," from whence obtained and how prepared for dyeing. This condition of affairs held up to the discovery and introduction of mauve, Perkin's discovery, from which time to the early eighties the so-called secrets of the dyers have gradually vanished, due in a great measure to the immense amount of practical technical data that is freely disseminated to all inquiries by the large color manufacturers. Consequently, the dyer of to-day is a much better technically informed individual than his earlier prototype, of which latter, however, there are a few still holding over; while realizing that important discoveries have been made, they still endeavor to convince themselves that the older methods were the most ideal.

Dyeing efficiency means getting the most out of a dye or given group of dyes. This means that the dyer should be sufficiently well informed by study and experieenc gained in a laboratory, to be able to recognize when a dye is yielding its best, and not stop at being merely a shade matcher. It is just here that the management of mills fails to secure proper efficiency in their dyehouses, believing that output is the only factor by which efficiency can be safely judged.

The purchasing department of a mill, notwithstanding the great amount of really valuable and authentic literature that is freely placed at the disposal of the color makers, cannot be expected to be fully informed as to the properties and characteristics of dyestuffs, as it requires special knowledge and training. To be intelligently informed regarding identity, tinctorial value and other properties requires laboratory aid of various kinds and a true index of mill efficiency is the use made of a well ordered laboratory.

One very large mill is gradually solving the problem of dyehouse efficiency in a manner that should serve as a model for all textile mills using aniline dyestuffs.

The equipment of this laboratory comprehends every phase of color testing, not only for the matching, of dyestuffs, but also for print tests. The system adopted is one which is perhaps the most practical that could be selected. Dyestuffs submitted to it are classified according to color, and as nearly as possible according to

shade. They are then dyed upon their standard woolen yarns, parallel shades of the same percentage strength. The object of this test is to determine whether or not a given dyestuff is stronger in tinctorial value than another. This test is supplemented by a further test showing the money value of two or more dyestuffs, the object of this series of tests being to ascertain whether, color for color, one dyestuff is cheaper or more costly than another. After having determined the relative tinctorial values of the series of dyestuffs, dyeings are made to show approximately the same shade and depth of color; then the yarn suitable is wound on cards of a few inches in width with bands of the several dyed skeins, and these exposed to the light for successive periods of seven days. The result of this series of tests then shows conclusively what dyes resist to the best advantage the action of direct light and those which succumb to this treatment. The entire system of testing dyes by this apparently complicated though very systematic method works out to the very best advantage of the mill; when the results are placed side by side, the chemist, the dyer and the designer have at hand all the available technical information necessary regarding the utility of any one particular dyestuff, and are consequently in a position to eliminate, according to the laboratory tests, dyestuffs which will not withstand the later and detailed processes upon the finished fabric. This particular phase of the laboratory's work serves as the most important lever to the dyehouse desiring to give the greatest efficiency to its mill.

A careful, systematic and thorough examination of any dyestuffs or groups of dyes of apparent value in a mill coloring textiles can be satisfactorily ascertained only by subjecting them to other kinds of tests that technical practice dictates. After having survived the intelligently conducted tests in the laboratory, the survivors may then be passed to the large laboratory, the dyehouse, or the print works with the fullest confidence on the part of the dyer or color mixer.

In the mill in question not only are the dyes so thoroughly tested, but the compound shades in which the fittingly surviving dyes are used are also made in the laboratory, the exact proportions being worked out and submitted to the designer. If the shades so produced pass the scrutiny of the designing room, all the information necessary is then passed on to the dyer who makes use of the foundation formula, worked out in the laboratory; this results not

only in a great saving of time in the handling of goods, but also in economy of dyestuffs. The surviving portion of the dyed skeins, print tests and exposure tests are systematically filed according to color, and are open to access to every one having business with the colors.

The buyer in this mill is consequently in a position to discuss intelligently, and in the best interest of his employers, the question of dyestuffs, and consequently is in a better position to judge on the merits of the various colors after having passed through such a systematically conducted and well ordered laboratory. Generally, the laboratory of a mill has been regarded as a needless expense, itself in the class of non-producing departments, but mills striving to maintain a position in the forefront of manufacturng excellence are beginning to regard a well directed and properly equipped laboratory as one of the most valuable additions to an intelligently directed purchasing department. The two must go hand in hand.

We hear very much to-day regarding fuel efficiency and it is without doubt that many buyers of the fuel of large mills are somewhat confused regarding the various consignments of coal, but having a laboratory possessing the important calorimetric apparatus, the purchaser is not groping in the dark regarding what he may expect to get from any specific shipment of coal. What applies to dyestuffs, or what applies to coal and other fuels applies with equal force to lubricating oils, heavy chemicals and other mill supplies.

As a general rule, American mills have not been as prompt to look into the merits of the various types of dyeing and bleaching machines and other apparatus designed to facilitate these two important operations, as have European concerns.

Without specific reference to any type or system, there have been brought to successful operation various forms of dyeing machines that are a great advance over the usual kettles and other appliances used in dyeing; the installation of these tends materially towards advancing the efficiency of the dyehouse.

It is a matter of fact that any dyeing or bleaching machine that conserves the condition of the textile material under treatment, other things being equal, is the ideal machine to adopt. When the mechanical handling of textiles during the bleaching and dyeing operations was first given attention by engineers, the one serious difficulty encountered was the very defective physical condition

of the finally dyed or bleached material. These defects, however, were gradually overcome by means of various expedients, so that at the present time there are a number of machines in use that imitate identically the best results that it is possible to secure by means of hand work.

This type of machine is included in rather a wide group of others, embodying the broad principle of working the material to be treated in the dye or bleach liquor, and generally requires a larger volume of liquor than other forms of apparatus.

Another group of machines is that based on the broad principle of circulating the dye or bleach liquor through the material to be treated, either with or without pressure, the result of which is that the dyeing is accomplished without any disturbance whatever of the condition of the material. In the early days of this type of machine, many setbacks were encountered, due chiefly to lack of penetration of the material by the liquors; thus many such machines were generally condemned. As experience was gained, it was found that the defective results were due entirely to a total lack of knowing how the apparatus should be loaded and packed; loose and indifferent packing always caused uneven results, while hard and close packing—leaving but small chance for leads and channels—always gave a dyeing or bleaching that was as close to perfect as possible.

Still another class of machines found especially valuable for loose wool is somewhat intermediate between the two general types above referred to, and consists of holding an amount of raw stock without any attempt at packing, and circulating the dye or other solution through it. The result in this case is a thorough dyeing of the fibers without any felting—a most serious evil, especially when handling the middle and higher grades of wool.

Reference to these mechanical aids in the dying and bleaching operations is made only for the purpose of drawing attention to what does exist, and the fact that there must be a demand for them sufficient to induce inventive dyers to go beyond the usual antiquated apparatus. From the common open kettle for skein yarn, in which the yarn is turned by hand, and which is in use to-day in many mills, to the crudest type of mechanically operated yarn kettles is a long stretch, but the later devices are gradually growing.

For years, and even to-day, the usual custom of handling warps

in the dyehouse is with open tubes and "boxes," through which the warps pass under and over submerged rollers, and it has only been of recent years that serious attention has been given to the dyeing and bleaching of warps "on the beam," that is, in spool form. The warps are wound tightly to the extent of many thousand yards on a special beam (spool), and by means of proper pumps the liquors are forced under pressure through the mass of wound threads. This principle of bleaching or dyeing is now only in its infancy, and I believe that in time it will be developed into the ideal manner of dyeing. While cotton cloth cannot be successfully dyed by this principle, it is quite possible to bleach by it, and it is not to be doubted that ultimately pieces may be dyed successfully in the same manner.

The textile industry is stimulated by constant competition, mill against mill, and while some mills appear to succeed with certain lines of fabrics, others making similar lines seem to be unable to forge ahead. In quite a number of such instances, careful investigation had shown that the difficulty to be overcome is the stoppage of leaks and losses in the handling of the goods in and from one stage of operations to another and by changing from obsolete methods, both mechanical and chemical, to methods that are modern and more in harmony with the spirit of the times. Many dyehouse and bleach works are absolutely non-efficient when compared with other departments of the same mill, and this is due in the majority of instances to the non-progressiveness and parsimonious policy of the mill, and also to the lack of initiative of the department foreman, who lags behind by not applying the advanced advantages of his particular line of work; in consequence, this department also lags behind—a millstone or an anchor—holding back the general progress of the mill. This is the condition that to-day confronts many of our apparently advanced and progressive mills.

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DEPRECIATION AND OBSOLESCENCE

By RICHARD K. MEADE.

Read at the Boston Meeting, June 25, 1913.

The capital invested in any manufacturing enterprise may be appropriately distributed among the following items:

(1) Plant.
(2) Working capital.
(3) Good will and patent rights.
(4) Laboratory and office buildings and their equipment.
(5) Mill site, real estate, mines, quarries, etc.
(6) The cost of financing.

Of these various items a few may be expected to increase in value as time goes on without any special provision other than that ordinarily attended with successful operation of the business. Other items become less even under the most careful management. "Good Will," of course, increases in value under successful management. The working capital may or may not be increased according to the policy of those at the head of the organization. The real estate will increase or decrease in value according to local conditions. The value of patent-rights grows less as the time of the monopoly granted under them diminishes. On the other hand where processes are employed under a royalty, the expiration of the life of the patent will allow these to be used without such expense. The deposits of raw materials, of course, decrease in value as they are drawn on to supply the plant. That portion of the capital which was devoted to raising the rest represents nothing of actual tangible value, although it is something which practically all manufacturing enterprises have to reckon with.

The value of the plant unquestionably gets less as time passes and the only way in which it can be maintained at anything like its original value, is by continually repairing the machinery and apparatus and by replacing worn out parts by new ones. Even when this is done, however, there comes a time when such replacement of parts will not be sufficient to keep the plant operat-

ing economically either because the cost of the repairs themselves is too great or else because the plant has reached that point of general dissolution when the breakdowns are so continual that the loss of time and output occasioned thereby is too great a handicap to be overcome.

In every plant, the expense of keeping the machinery in satisfactory working condition is taken care of by the current expenses, but very few plants have made any provision against the time when the entire plant must be rebuilt. Unquestionably such a fund should be provided, or in other words if the plant is to be self-perpetuating a fund should be set aside during the life of the plant for its replacement when it goes out of commission.

Most manufacturing enterprises frequently meet with extraordinary expenses, due to the breaking down of individual units. These breakdowns may come within a year or so of the starting up of a new plant, whereas the actual life of the plant itself may be many times this. If these expenses are allowed to come in the ordinary monthly cost sheets these latter will show irregularities and will not serve so well as an indication of the operation of the plant during the period in which they occur; consequently it is desirable to have a certain fund available which can be used for such renewals.

These two funds one for replacing units as they go out of commission and the other for rebuilding the entire plant, constitute the depreciation account. The former may be termed "current depreciation" and the latter "plant renewal depreciation." The former is to be used for the replacement of any individual units and the latter for the replacement of the entire plant.

To draw a parallel from the cement industry let us take for example a cement kiln, these are long horizontal cylinders, revolving slowly on rollers and heated by a jet of pulverized coal or oil so that a temperature is maintained in them of about 2500° F. The lower part of the lining is subjected to the scorrifying action of the charge and this part needs to be replaced about once every year. The cylinder itself, however, will last fifteen to twenty years. The replacement of the lining of the kiln should be taken care of by the current depreciation. There comes a time, however, when the outside shell of the kiln becomes worthless and when the entire apparatus must be replaced, and for this purpose we should be able to draw on a plant renewal

fund. The proper plan, therefore, would be to estimate the average cost per year of repairing the lining and set aside a sum sufficient to cover this, crediting this sum to the current depreciation account. At the same time the life of the shell should be calculated and a sum sufficient to cover the replacement of this at the end of its usefulness should be set aside and credited to the plant renewal fund. In the purely chemical industries the lead chamber offers an illustration of a piece of plant apparatus which must be replaced some day practically *in toto*.

Sometimes a machine is renewed part by part as these wear out, so that at the end of a period of years there is probably in its make up not one part originally present in the machine when it was first put on its foundations. Certain types of pulverizing machinery offer a good illustration of this. For example with mills of the type of the Griffin and the Fuller-Lehigh mills, which are subject to constant repair, it is a fact that any of these mills which have been properly kept in repairs will be practically as good at the end of ten years continuous operation, as they were on the day on which they were installed. On the other hand, with the tube mill for example the cost of repairs are much lighter but there will come a day when the entire mill must be replaced and the cost of such replacement will practically represent the cost of a new tube mill.

Depreciation of the value of a machine may also be caused by the working out of other and more improved machines, by the discovery of a more economical process for the working out of the finished product from the raw materials in which this machine is not used, or even by the demand of the trade for a product that the original machine is not capable of producing. Such depreciation is now generally considered as a separate and distinct item known as "Obsolescence."

Where enlargement of the plant is made necessary by an increase in the demand for the product, this can be properly financed by increasing the capital if necessary. Such enlargements are in no way concerned with depreciation because for depreciation the original plant must actually depreciate in value. When new apparatus taking the place of the old has a greater capacity than the original apparatus, part of the value of the former may properly be added to the capital account but a part of it should certainly be taken care of by depreciation.

At the present time, competition in practically all industries is much keener than it was ten years ago and profits are much less. The introduction of the cost system has enabled manufacturers to determine accurately the factory cost of producing their goods and many large manufacturers have been willing to undertake business using this system as a basis and figuring from this the prices of their product, allowing a fair return on the capital invested. As the results of this blind following of the system and the failure to take into consideration depreciation, etc., prices have often been figured far too low. It can be safely said that one of the first effects of keen competition has been to make manufacturers rely too closely upon the cost system in fixing prices. Ordinarily installed as a method of furthering the economic operation of the plant, it has of late years become the basis of prices themselves. Of course, the mill cost is an item in fixing the price at which a product may be sold but if a manufacturer considers only the cost of labor, fuel and supplies in making his prices he will sooner or later come to grief.

In many concerns, the failure to carry a depreciation account and the distribution in dividends to stockholders of money which should have been set aside for plant renewal has resulted in their ultimate financial distress.

Replacements are often made necessary by fire, floods, storms, explosions, etc. Such replacements can be properly made from the depreciation fund because new apparatus is installed and the opportunity can be taken to equip with improved forms of the latest design in place of the older type.

Obsolescence cannot be stated and figured so scientifically as depreciation. Certain things, however, can be borne in mind in considering this. Obsolescence as a general thing grows less as a process grows older. In every industry, the change and improvements which occur in its early years are much greater than those which occur later. Much of the obsolescence which has occurred to plants in the last few years has been due rather to need for greater outputs than to any actual inefficiency of the earlier apparatus itself as compared with the later forms. In many industries, the general concession seems to be that plants have now reached the most economic size for a unit.

I might express my idea of obsolescence in the form of a curve (figure 1) in which one ordinate is the rate of obso-

lescence and the other time. Such a curve will take the form of a hyperbola. It is easy to conceive, however, that there may be a break in this curve due to some discovery which would revolutionize the art of manufacture in this industry. Such discoveries, however, have seldom been of such a nature as to put out of business old established concerns which could not adopt them immediately. Time is required to perfect the workings of a new process and most plants which are under competent management are informed of the discovery in sufficient time to make preparation for its adoption should it become universal.

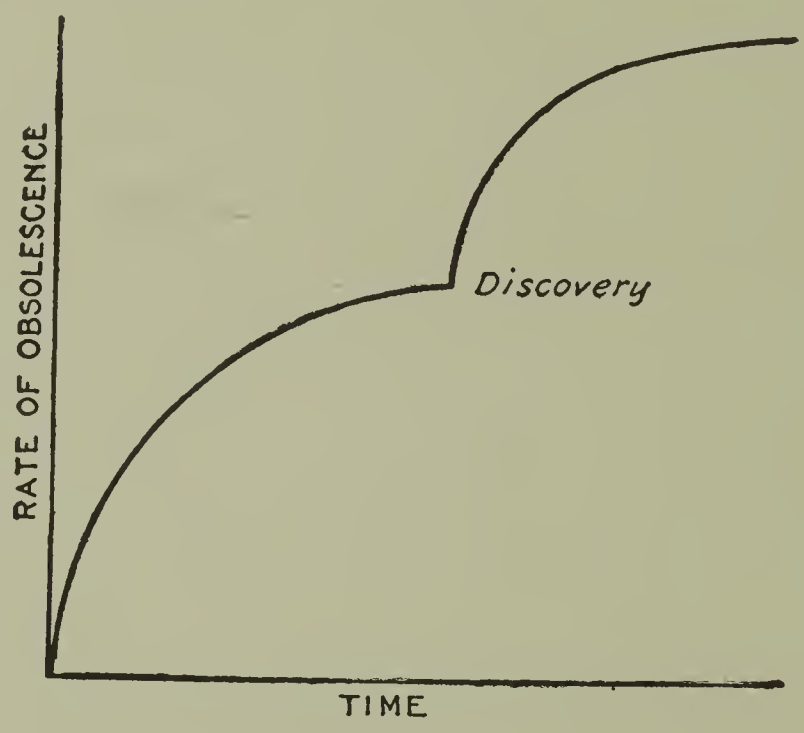

FIG. 1.

As examples of radical changes in processes and the slowness of the newer and theoretically much more efficient process to displace the older process, may be mentioned the electrolytic method for soda and the contact process for sulphuric acid. In spite of its apparent simplicity and marked advantages over the older methods, the electrolytic process for soda has not yet overtaken the older Solvay process. This process is fifty years old and altho it had now displaced the Le Blanc process to a great extent it has required half a century to do it in.

In the case of the contact process, the improvements in lead chamber practice seem to keep pace with the advances made in the operation of the former so that ample time will be given manufacturers to change from the older process to the new should the latter prove ultimately to be the more efficient.

Most processes change detail by detail. Much apparatus in the old one could be used in the new: notably buildings, power plant equipment, conveying machinery, etc. The most radical changes which could occur would probably be the substitution of a furnace process in place of a wet reaction one, or from a simple chemical process to an electro-chemical one.

As an example of such a possible change, processes are being investigated at the present time for rendering available the phosphoric acid in phosphate rock by furnace methods. This if successful and universally adopted would decrease the consumption of sulphuric acid fifty per cent and cause the sulphuric acid plant now a prominent part of many large fertilizer works to become worthless and necessitate the installation of rotary kilns and pulverizing plants in its place.

The scarcity of labor might at any time cause machinery to become obsolete owing to the need of replacing men by machines. In certain sections where labor is now cheap it is easy to foresee conditions where an increase in wages might necessitate the entire re-construction of a plant.

Obsolescence generally determines the value of the mill site. Since this is of course subject to no physical deterioration and is effected only by the need of moving the plant to a more advantageous site relative to climate, markets, raw materials, labor or transportation facilities. In certain industries such, for example, as the manufacture of Portland cement the extinction of the raw materials would effect the value of the mill site because when the raw materials are exhausted it will be necessary to move the plant to some other location. This form of obsolescence, however, can be calculated with the same degree of accuracy as depreciation.

How to handle depreciation best is a question which is open to considerable discussion. The ideal plan is unquestionably to set aside from the profits a certain sum each year. This amount should be derived by a very careful study of the machinery and buildings and other appliances and assets of the company, including the patent rights. In every business, there are good years and bad years and it will probably be found, therefore, to be impracticable to set aside a fixed sum each year because there are times when even the most careful management will fail to make both ends meet, so that the good years must bear the heavy burden.

The depreciation account as we have said should be divided into two parts, one for use immediately and one as a reserve. The former should be used to repair break-downs and make renewals of machinery of an extraordinary character and the second for the renewal of the entire plant. The first is designed principally in order that the manufacturers' cost sheets may not vary too widely from month to month owing to unusual repair items, and may serve as a reliable guide to the operation of the plant during various periods. In some industries the repairs are small and the replacements are light, and in these, such a drawing account may not be necessary but in most chemical metallurgical and mining plants there should be set aside such a fund. There should also be set aside a sum representing the depreciation of the raw material deposits if there are any.

In plants which are financed entirely by the use of bonds there is usually a clause in this latter which provides for a sinking fund sufficient to retire the bonds after a certain length of time. Plants which are financed in this way do not need a "plant renewal depreciation fund" because if their bonds have been retired, new securities can be issued and in this way sufficient funds may be raised to cover the cost of the plant renewal.

If depreciation is placed at too high a figure manufacturers will be inclined not to consider it or if they do stockholders will be cut off from dividends which are rightfully theirs. The argument that the surplus is an asset of the company and consequently the value of its securities is increasing is not to be considered as answering this argument because many trust funds, etc., are invested with a view to bringing in steady revenues to the investors.

The question of depreciation is not simply one for the board of directors and the financing committee only. It is also a problem for the plant superintendent, the engineer, the chemist and the geologist. It is only by a careful and scientific study of the subject that a proper figure can be arrived at. No two industries present the same conditions and probably no two plants manufacturing the same commodity will have the same life, hence depreciation is his particular problem with every manufacturer.

Obsolescence is always an unknown quantity and in a new industry it is much harder to gauge the rate of this than in an old one. Generally speaking in most established industries the amount set aside for depreciation will also cover obsolescence.

Whenever the successful working of the plant is dependent

upon a limited supply of raw materials, the life of the plant is fixed by the length of time the raw materials will last rather than by the wearing quality of the machinery. The depreciation fund in this case is of course the cost of replacing the plant and property.

As the first step in fixing the depreciation fund the expert should consider the question of raw materials. If a local supply how long will it last? Even if brought from a distance the possibility of having to go still farther for it should be considered. Can new property be had at the cost of old? If the quality of the new materials is decreasing, making it less easy to fashion the finished product as time goes on and possibly causing increased equipment, this should also be considered and provided for.

Next the present equipment of the plant should be considered. Is it efficient and how soon will it have to be replaced? Each price of apparatus should be tabulated according to its probable life and value. Apparatus which needs to be replaced at the end of a year or so should be classed under the current renewal fund, and that with a longer life under the plant renewal fund.

From the plant renewal fund list, should be excluded all apparatus which breaks down part by part, such for example as bucket elevators, screw conveyors, Griffin mills and all small apparatus whose replacement represents a comparatively small sum such for example as acid eggs, cast iron evaporating pans, nitre pots, etc.

Most apparatus has a salvage value even if only sold for its metal to the junk dealer. The amount of this may be calculated and deducted from the cost of new apparatus or it may be neglected altogether and considered merely as furnishing a margin of safety.

Let us take for example a cement plant of 3000 bbls. daily capacity built say in the last year or two and equipped with ball and tube mills for grinding the clinker, and Fuller-Lehigh mills for grinding the raw materials, electrical drives, etc.

The capital raised for this will probably be distributed as follows:

Plant and quarry equipment	$1,000,000
Property	100,000
Office and Laboratory	15,000
Working capital, bags, etc	235,000
Cost of financing	150,000
Total	$1,500,000

Let us consider the amount of raw material to be sufficient to last at least forty years. In considering the amount to be charged off for the extinction of the raw materials, the question is not merely one of present value but rather of the cost of replacing the property by a new one at the end of its usefulness. Since the life of the property is far greater than that of the plant the latter will probably have been re-built several times before the extinction of the raw materials.

In the plant itself unquestionably much of the apparatus would have been replaced piece by piece in the course of current renewals.

An estimate of the cost of such a plant showing the distribution is given below:

COST OF BUILDINGS AND EQUIPMENT.

3000 Bbl. per Day Portland Cement Plant.

Buildings	$200,000
Crushers, screen, etc.	25,000
Dryers, coal and raw materials	25,000
Raw Mills (Ball Mills & Fuller Mills)	70,000
Kilns and equipment	75,000
Coolers	20,000
Clinker Mills (Ball and Tube Mills)	75,000
Coal Mills (Rolls and Fuller Mills)	14,000
Elevators	50,000
Bins and Stock Boxes	40,000
Shafting, pulleys and belting	20,000
Foundations, Tunnels and Concrete Work	40,000
Power Plant Equipment	175,000
Motors	40,000
Wiring and Electrical Work	30,000
Machine Shop, carpenters' shop and blacksmith shop equipment	10,000
Miscellaneous equipment	41,000
Quarry Equipment	30,000
Tracks, Coal Trestle and Yards	20,000
	$1,000,000

The above estimate includes the cost of installing the machinery and also its proportion of the engineering work, superintendence, clerical work, accident liability insurance and other items incident to construction.

If the mill and kiln buildings are of steel it would be safe to estimate their life if properly painted and taken care of at from forty to fifty years. Depreciation on steel mill buildings is usually considered at 2 to 2½%. If the stone-house and the stock-house are of concrete with steel roof trusses, their life should even be longer. The roofs and sidings to the building would probably not have a longer life than 15 to 20 years, so that the average life of the buildings could be safely placed at thirty years. It is hardly likely that they will become obsolete as modern machinery generally is more compact and, even if otherwise, steel buildings can be very readily enlarged.

No figures are obtainable upon the life of the kilns. Some seven or eight years ago the size of the kiln was changed so that the long kilns now in use are none of them older than about ten years. These kilns do not show signs of going generally to pieces, altho in some cases a lower section (25′) may have to be riveted on. I think that 20 years would be a safe estimate of the life of an 8′ × 125′ kiln.

The dryers and coolers are subject to considerable wear and tear—the latter particularly and the rotary coolers wear faster than the upright ones. The life of a stone dryer on hard limestone is generally about 15 years and of a coal dryer not over 10 years. The crushers will last at least 20 years. Ball and tube mills should last this long also. Both, of course, need lining frequently. Griffin, Maxecon, Sturtevant, Hammer and Fuller mills are practically built over every few years. I think that with the ball and tube-mill installation 20 years would be liberal, as I know of mills which are still running efficiently which are nearly this old and which are probably good for many years more. The quarry equipment is subject to much wear and tear and I do not believe the life of steam shovels, cars and engines will be much more than ten years.

On engine boilers and power plant equipment the figures generally used are from 5 to 6⅔% or a life of from 16 to 20 years, and motors in cement plants where they are subject to dust, can not be expected to have much over 15 years of efficient life.

The bins and stock-boxes are quite an important item in the cost of a cement plant. These are not subject to appreciable wear and their life can safely be figured at 30 to 40 years. Furthermore they are not subject to obsolescence and, in most plants with whose remodelling I have been connected, the bins in the old plant have been used in the new one.

Some of the concrete is in the foundations for the machinery and buildings and some of it in dams, retaining walls, tunnels, coal-trestles, etc., about the plant. Of itself, it is practically indestructible but is, of course, subject to obsolescence, particularly the foundations which may not suit the new machinery to be installed.

Machine shop tools are usually figured having a life of 20 years and accurate figures are obtainable on these. The tools in the cement plant machine shop are simple (lathe, drill-press, planer, etc.) and are not subject to very great obsolescence.

Wiring and electrical work if substantially done, as should be the case if the figure given in the estimate is adhered to, may be safely assumed at the figures used by various electrical railroads, etc., for indoor wiring, viz., 20 years.

Shafting, belting and pulleys will for the most part be taken care of by repairs but these are also subject to obsolescence in that they may not suit the new machinery.

Elevators and conveyors are subject to rapid wear and their renewal will come under repairs. The casings, metal troughs, etc., will have a long life consequently these should be taken care of in the plant renewal fund.

The miscellaneous equipment is for the most part made up of small items many of which are subject to renewal as repairs, etc.

Re-arranging the items in the above estimate of the cost of the plant to their probable life we have the following:

PRACTICALLY INDESTRUCTIBLE		
Concrete work	$40,000	$40,000
30 YEARS		
Buildings	$200,000	
Bins and stock-boxes	40,000	
		240,000

20 YEARS

Crushers, screens, etc.	$25,000	
Kilns and equipment	75,000	
Clinker mills	75,000	
Raw ball mills	15,000	
Coal rolls	2,000	
Machine shop equipment	10,000	
Wiring and electrical work	30,000	
Shafting, pulleys and belting (25%)	5,000	
Elevators and conveyors (40%)	20,000	
Miscellaneous equipment (50%)	20,500	
		277,500

15 YEARS

Power plant equipment	$175,000	
Motors	40,000	
Stone dryers	15,000	
		230,000

10 YEARS

Coolers	$20,000	
Coal dryers	10,000	
Tracks	20,000	
Quarry equipment	30,000	
		80,000

TAKEN CARE OF BY CURRENT RENEWAL FUND

Fuller-Molls	$67,000	
Shafting, pulleys, and belting (75%)	15,000	
Elevators and conveyors (60%)	30,000	
Miscellaneous equipment (50%)	20,500	
		132,500
		$1,000,000

In arriving at the proper figure for depreciation, therefore, we must provide for $80,000 at the end of 10 years, $230,000 at the end of 15 years, $277,500 at the end of 20 years, $240,000 at the end of 30 years, and $187,000 at the end of 40 years when the raw materials become extinct. This latter sum includes the value of the office and laboratory. The amount to be set aside each year is found not by dividing $80,000 by 10, etc., but calculating the sum which placed at compound interest will net $80,000 at the end of 10 years. It is inconceivable that such a fund set aside each year would not bear interest. If invested in the business itself in the form of enlargements, etc., the depreciation fund should be credited by its earnings. A depreciation fund could be safely invested at 5% interest and the interest so obtained re-invested

with the new installments to the fund as they are set aside. So it seems perfectly proper in setting aside such a fund to assume that it will bear compound interest for say at least 5%.

A table calculated by Mr. John W. Hill, and first published in *Engineering News,* Jan. 25, 1894, for calculating this sum will be found in Kent's "Mechanical Engineers' Pocket Book," page 16.

In the above case the sums to be set aside annually are as follows:

To provide	$80,000	in	10	years	.....	$6,360
" "	$230,000	"	15	"	.....	10,666
" "	$277,000	"	20	"	.....	8,392
" "	$240,000	"	30	"	.....	3,612
" "	$187,000	"	40	"	.....	1,548
Annual Depreciation Fund						$30,578

As the above plant will probably manufacture from 900,000 to 1,000,000 bbls. per year this sum will be equivalent to from 3.01 to 3.4c. per bbl. of cement produced.

On the extinction of the raw materials, two courses are open, one to retire entirely from business or to secure some other source of these and build a new plant at the new location. If the first course is followed, the depreciation should be increased by a sufficient sum to retire all of the securities at the end of forty years. The working capital at this time will most of it represent bills receivable and hence no provision need be made for retiring this. That portion represented by bags will probably be cut in half but this will be offset in most cases by receipts from the sale of land, old machinery, buildings, etc.

The amount of depreciation to be fixed upon therefore in case plans are made to go out of business will be the amount necessary to provide $250,000 in forty years or an annuity of $2070 equivalent to from 0.23 to 0.21c. per barrel, making the total depreciation in this event from 3.24 to 3.61c.

If new property is to be acquired it is probable that this will be purchased as the opportunity presents itself to acquire desirable deposits of raw materials rather than at the expiration of the life of present holdings, and it is probable that the transaction would be financed by the surplus profits of some period of good prices rather than by any fixed annuity.

In fixing a price for the cement, however, the cost of the raw materials as represented by the purchase price of the property should be included. Or considering the life of the deposit as forty years, or 40,000,000 barrels, 0.25 cent should be added to the cost of production to cover the "in the ground value" of the raw materials.

In my estimation the sum of 10c. per barrel urged by some cement manufacturers recently is much too high. While it may be the part of wisdom to set aside some such sum as a contingent fund there seems to be no need of any such figure for depreciation alone.

LEGAL CONTROL OF DANGERS TO HEALTH IN FACTORIES

By CHAS. F. MCKENNA

Read at the Boston Meeting, June 26, 1913.

Legislation against allowing unhealthful conditions to emanate from factories has enlisted attention since the earliest days of the factory system, and comprises a great literature and body of laws and decisions. Strange to say many years passed before the hygienic dangers *within* the walls of the factory began to receive similar attention, and much of the knowledge and experience on which to found the necessary protective statutes are still to be gained.

In the first case, that is of neighborhood nuisance, the factory managers and empolyees seem to think that they have common cause against the public; in the other case the employees are sometimes indifferent and sometimes actually or constructively arrayed against the managers. Just how far this latter attitude is justifiable can only be determined in the future when knowledge shall replace surmise, and confidence takes the place of distrust. In the very recent past, however, there has been very great development throughout this country in restrictive legislation aimed at bettering the health conditions of factory operatives.

Under the expert guidance of Dr. Charles P. Neill of the Bureau of Labor, in the Department of Commerce and Labor, and under the spur of the American Association for Labor Legislation, directed by Dr. John B. Andrews, and very importantly in New York State under the skilled guidance of Senator Robert F. Wagner and Mr. Abram I. Elkus, Chairman and Counsel respectively of the New York State Factory Investigating Commission, very great advance has been made in a moderately short time.

I am afraid that many owners and managers have failed to follow the searching inquiries very properly planned and carried out as the first step in this good legislative work, and that they

have also lacked interest, and some perhaps have acquired a deeper hostility to many efforts of the kind. I know of one case of the first mentioned indifference and ignorance, where a new chemical factory was being erected and neither architect nor owner knew at the very beginning of the work of erection that a new law of the previous session was just going into force, which would call for a very material devotion of space for toilets and wash rooms. This space would be hard to provide after the completion of the factory. A very large number of other new requirements were also at the same time under discussion in the current session, some of which if passed as they have been since, might call for further modification and embarrassing changes in this company's plant.

This seems strange in New York State where this changing legislation has been thoroughly well covered in the news items of the press, and where public hearings have been called and fully heralded in numerous localities on numerous occasions.

We do not usually find this indifference among those large interests whose materials or methods have long been noted as eminently threatening to the worker, such as lead manufacture, the chrome industry, etc., for they of course have had history and striking personal experiences to keep them alive to their duty of attempting amelioration, so that they have joined heartily with the sanitarian, the humanitarian and the legislator to do their share of this duty.

In the course of this agitation we heard much of Occupational Diseases. These are diseases contracted as a result of the nature of the patient's employment. Universal interest has been excited in the subject by reason of distressing results found the world over in three certain trades, namely: white lead and other lead manufactures, phosphorus and match manufacture, arsenic and paris green manufacture. Nearly always when the subject of occupational diseases was taken up it has resolved itself into a discussion of these industries. They may be of the widest extent and most striking and most generally distressing. They may be, I say, for we do not really know by comparison with others. We have nothing definite, expressed in measurable terms to tell us how generally workmen suffer and wilt and slowly die through no fault of their own, from no exposure at home or on their way to work, but strictly and solely from some insidious evil effect connected only with the conditions of their regular employment.

Do these perilous conditions exist? Are they persistent and characteristic of the industry? Are they curable or palliatable? We must know before we can proceed with legal control by fair and practicable means.

In an investigation last year covering a great number of industries in New York State, in which it is generally believed that seriously insalubrious conditions prevail, it was impossible to secure statistical data and almost impossible to uncover the overlying encumbrances of custom, indifference or greed in order that the truth may be gotten at. Truth can hurt no one. With this as a certainty, a steady movement has been in operation for a number of years, mainly under the impulse of the American Association for Labor Legislation, looking to the introduction of a system by which truthful data upon this subject can be obtained. This has taken the form of a legislative bill calling for occupational disease reports from physicians. This bill is now in a standard form in which it has been passed by the legislatures of fifteen States. It is brief, and I give it here:

"An Act to require the reporting of certain occupational diseases, and to provide for its enforcement.

"Be it enacted, etc., as follows:

"Section 1. Report of Occupational Diseases.

"Every Physician in this State attending on or called in to visit a patient whom he believes to be suffering from poisoning from lead, phosphorus, arsenic brass, wood alcohol, mercury or their compounds, or from anthrax, or from compressed air illness, *or any other ailment or disease, contracted as the result of the nature of the patient's employment,* shall within forty-eight hours send to the state board of health a report stating:

"(*a*) Name, address and occupation of patient.

"(*b*) Name, address and business of employer.

"(*c*) Nature of disease.

"(*d*) Such other information as may be reasonably required by the state board of health.

"The reports herein required shall be on or in conformity with the standard schedule blanks hereinafter provided for. The posting of the report, within the time required, in a stamped envelope addressed to the office of the state board of health, shall be a compliance with this section.

"Section 2. Blanks for Reports.

"The state board of health shall prepare and furnish, free of cost, to the physicians included in Section 1, standard schedule blanks for the reports required under this act. The form and contents of such blanks shall be determined by the state board of health.

"Section 3. Reports not evidence.

"Reports made under this act shall not be evidence of the facts therein stated in any action arising out of the disease therein reported.

"Section 4. Penalty.

"Any physician who neglects or refuses to send the report or reports as herein required, shall be liable to the State for a penalty of——dollars for each offense, recoverable by civil action by the state board of health.

"Section 5. Transmission of Reports.

"It shall furthermore be the duty of the state board of health to transmit a copy of all such reports of occupational disease to the (proper official having charge of factory inspection).

"Section 6. Time of Taking Effect.

"This act shall take effect on———

Accidents occurring in factories have of course for many years in most States, been by order, reported to the State Labor Department. Indemnity has also been the subject of much legislation, aiming at securing adequate and equable charges on the industry for compensation for accidents. Undoubtedly when occupational diseases shall have been well studied, their cause, effect and economic destruction truthfully appraised, indemnity will be provided for. Thus the evolution will reach the practical effect of a pension system. I repeat that all that is needed is truth as to the facts.

But there are hygienic conditions in factories which recent laws have aimed to improve, which lead to results which cannot always be recognized as occupational diseases. I refer to such care of employees as furnishing toilet conveniences, washing apparatus and eating places. Some managers put on a wearied air when asked as to these, and they frankly state that the nature, habits and customs of their employees will have to change before these provisions can be anything else but waste—a waste of human kindness and a waste of material and money. Unquestionably, nevertheless, indifference to providing ordinary facilities for men to secure their

daily sanitary needs can reach the proportions of a great wrong. How would you classify in the scale of humanity a manager who would work his men at furnace work and then let them go down to the dock, regardless of the cold winds, to find there overhanging the water the toilet conveniences? Shortening his life's span, and damaging the workman's civic asset value may not upset the operation of the plant when there are plenty of men at the gates to take the sick man's place; but if it is done thus, it is done with extraordinary ignorance of the consequences. There are not many managers who act thus, but it ought not to be always incumbent on the law to seek them out.

There are other diseases again which probably arise from the simple causative matter of dust. It is probable that this feature of the study of occupational diseases is the one which will give the most trouble by reason of doubt in recognition of the cause and effect. It was on account of this lack of definite knowledge of conditions and needs for ventilation, fume removal and general ameliorative conditions and the impossibility of meeting the necessities by annually amending the laws that the New York State Legislature has acted favorably on recommendations of an admirable State Factory Investigating Commission, which has sat for two years and provided a flexible and just system of laws. The only proper way to describe this legislation is to quote almost in full from the able Counsel, Mr. Abram I. Elkus:

> As a result of the Commission's work thirty-two bills were recommended to the Legislature;* they cover a wide range, beginning with the recommendation for the installation of automatic alarms in case of fire, fire drills, the installation of automatic sprinklers-systems to prevent the spread of fire and to extinguish it, the limitation of the number of occupants of factory buildings, according to the number and width of exits, the regulation of stairways in existing buildings; and, finally, a complete code to govern the erection of future factory buildings, so that they may be absolutely safe as far as human ingenuity can make them.
>
> Statutes with reference to the proper ventilation of factories, washing facilities for workers, sanitary arrangements, cleanliness of workrooms in factories and mercantile establishments, appropriate inspection of the same, and, most important of all, an entirely new and scientific reorganization of the labor department.

* They have since been passed unchanged and will become operative Oct. 5, 1913.

The labor department heretofore has not been placed in its proper position. It has not only been regarded more or less as a minor department, but, worse than that, as a police department to detect technical wrongdoing under specific statute and to attempt to punish it when detected. Its true function as a department of education with initiative and will to bring about a closer and more friendly relation between worker and employer has been absolutely neglected.

These bills attempt to provide the machinery to bring about such a result. They aim to raise the labor department to the high place which it deserves.

* * * * * * *

At the outset the Commission had to consider in reorganizing the labor department whether it should be placed in charge of a Commission or of a single man. The Commission believes it has solved this problem satisfactorily. It did so after consulting with practically every social worker of any prominence in the State of New York, receiving his or her opinion. The commission form of reorganization is created to make and enact rules and regulations and conduct investigations, etc., but the Commissioner of Labor, a single individual, is made the executive head of the department and upon him is placed the responsibility for enforcing the laws and regulations. There can thus be no shirking of responsibility nor division of power which has existed where a commission obtains.

The three bills which relate to the reorganization of the labor department provide in substance that the Labor Commissioner shall receive a fair compensation, increasing somewhat the salary now paid in order to get a man of ability and character to accept the position, and also in accordance with the increased cost of living. There is to be a reorganization of the bureaus which now exist. There are now five bureaus. They are to be made into four, but the commissioner has power to create any new bureaus which he may desire. It is provided that branch offices be maintained in the city of New York and in other cities as the commissioner may deem advisable. The powers of the bureau of statistics which is now in existence and which has done excellent work, are enlarged. This bureau shall have five divisions,—general labor statistics, industrial directory, industrial accidents and diseases, investigations, and printing and publication. In these different bureaus there shall be collected statistical details and general information in relation to all departments of labor in relation to all the conditions of workers in the industries of the state. Industrial accidents are required to be collected, assorted and systematized. Full details and information regarding them, and also occupational diseases, their causes and effects, and such methods as may be recommended for preventing, curing and remedying them and of providing compensation therefor, shall be investigated

and compiled. The division of investigation shall have charge of all investigation and research work. The commissioner of labor shall through the Division of Printing give such information and statistics as he believes will promote the health, safety, and well-being of the workers scattered throughout the state. This function requires that the department shall be a deparment of education.

It is the experience of the Commission that in many cases the manufacturer was entirely willing to remedy existing conditions if he knew how, but that he had not been told, and there was no way of enlightening him.

It is proposed through this means to help the manufacturer to help himself, and at the same time to help his employees.

The Bureau of Inspection is reorganized under competent heads so as to place undivided responsibility for proper inspections upon one man, and that there cannot be any excuse for failure of proper inspection. There shall be a division of this inspection into four classes,—factory, home work, mercantile, and industrial hygiene.

It has been the experience of the Commission that proper inspection will remedy many of the conditions of which complaint is now made. Since the Commission has been in existence and because of its own personal investigations of many establishments and of the activity of its employees, it is conceded that there has been a marked change for the better in many of the manufactories of the state.

At this point it is but fair to say that we have in this state manufacturers of the best and highest citizenship, whose factories are models, whose workers are well paid, and who work and are required to work reasonable hours. But this condition, unfortunately, does not apply to all of our manufacturers.

The number of inspectors are required to be not less than 125, of whom not more than 30 shall be women. The inspectors are divided into seven grades, according to service and duties.

A new and very important division is created by this act—that of industrial hygiene, which includes medical inspection. The Division of Industrial Hygene will consist of a physician, a chemical engineer, a mechanical engineer, who shall also be an expert in ventilation and accident prevention, and a civil engineer who shall also be an expert in fire prevention and building construction. This will be an unique expert board, which will have the right and power to advise employers in factories and mercantile establishments how to conduct their business, so that it will be scientifically correct and yet be of benefit to themselves and their employees. This board shall have the power to conduct special investigations of industrial processes and conditions. It is required to prepare for distribution leaflets and bulletins calling attention to dangers in particular industries, and to precautions to be taken to avoid them.

The section of Medical Inspection of this Bureau shall inspect factories and mercantile establishments with respect to conditions af-

fecting the health of employees and of the children particularly, so that measures may be taken to improve their health.

There are many other provisions in this act to carry out the general outline which I have given. The act to create the Industrial Board is perhaps the most important step forward in legislation which has been taken in this state in many years, if ever.

The work of the Commission has made it realize that it is impossible to legislate definitely by statute, so as to cover every detail of every business in this great State. The attempt to do this in the past has been largely responsible for the futility of the present labor law and the inadequacy of the labor department. As soon as a statute was drawn which was supposed to cover certain evils it had scarcely been placed on the statute books before it was discovered that it would be practically impossible to enforce it against many industries and it became a dead letter. Stringent regulations which were perfectly proper as to one business were unnecessary and unfair to others. It was then decided after careful and mature deliberation that the only way to meet this situation was to create a board as part of the labor department, which would have the power to make regulations, which would have the effect of statute under some broad general statute giving general powers, and prescribing a minimum or maximum of the things which were required to be done. This statute creates such a board and gives it such powers. Briefly, there are to be five members of the Industrial Board. This name was suggested after much thought, and seems to epitomize the purposes and powers of the work of the board. The labor commissioner is to be the chairman of the board, is to be appointed by the Governor, to be affirmed by the Senate, and to be removed as similar officers are removed.

In its report the Committee will recommend to the Governor that the composition of the board shall consist of one woman, one representative of labor, one representative of employers, and one a scientist. The board is required to meet at least once a month. For the first six months of its existence it will have to be in almost daily session to promulgate the rules and regulations required of it by the Act. The board is given power to make investigations with reference to all matters covered by the Labor Law; to make personal inspection of all buildings; the power of subpœnaing witnesses; to make rules carrying into effect the provisions of the Labor Law; to make and to alter rules to regulate and guard against and minimize fire hazards and personal injuries and disease, with respect to the construction and equipment of factories and mercantile buildings in regard to the limitation of the number of persons who may occupy the same, the guarding of machinery, the conduct of employers and employees in and about factories and other buildings.

The rules thus made shall have the force of law. They may be limited to particular trades or to particular localities. The great

flexibility thus attained ought to be productive of the greatest good.

The rules may be changed, if necessary, over night, although provision is made for the due publication of all rules and their changes.

Other bills among the thirty-two presented give broad general powers to the Industrial Board with reference to the remedies there sought to be created and enforced, such as the lengthening of hours by permission of this Industrial Board in the canneries of the state, and the increasing of the number of occupants of buildings under certain conditions. In every case like this the Commission may investigate personally either as a whole or by one or more of its members or through the Division of Hygiene, and at once make a new rule to meet the exigencies of the situation or refuse its permission if conditions do not warrant.

This system has worked satisfactorily in many of the countries of Europe. It will serve to place in close touch the officials of the Labor Department with the work and the employee, it will make them feel that the Department of Labor is not a mere police department but a department which is earnestly, honestly and intelligently endeavoring to help the worker and manufacturer to attain better things with greater ease.

The third bill to which I have referred provides for the increase of the number of inspectors and the reorganization of the department so far as it relates to the inspection of mercantile establishments.

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To this excellent compendium of an admirable body of laws, I can only add the wish of all connected with the passing of them, that the good intention shown by some of the foremost corporations and managers in our State to co-operate with the Labor Department may be imitated by all manufacturers and employers, and that a close entente with their men may come from a greater enlightenment just as greater profit will surely come from securing a healthier tone for them.

Much opportunity also exists for the inventor and the Chemical Engineer to modify processes found insalubrious to such degrees that the remedy shall be found rather in natural changes than in drastic legal restrictions.

LOW AND MIXED PRESSURE TURBINES

By J. G. CALLAN*

Read at the Boston Meeting, June 26, 1913.

Low pressure turbines constitute a specialized engineering subject, but one of common interest to us all, as are all subjects that have to do with power, since power is not only the common property of engineers, but is, in a degree which we do not always recognize, the common ground of meeting for all the material things which have made our present civilization. Other and earlier races were near enough to us in the evolutionary process so that we may safely assume that their brains, their work and their conceptions were about as good as ours would have been under their conditions. Their environment they found different from ours in many things, but most of all in the absence of power. Our civilization may be said to be founded on a corner stone of coal.

Now when we speak of power, we think quite properly of coal, although power from sources other than coal are by no means negligible. The use of water power is increasing at a rate which is difficult for those of us who are not specialists to realize; gas and crude oil engines, especially the well known Diesel engine, are also having a rapid development; and one particular source of power, the gasolene engine as typified in the automobile, is becoming a very considerable factor in the total engine horsepower of the country. The mainstay of the power situation, however, is coal, and it will probably remain so until we get something from the atomic forces.

Before we pass from the subsidiary sources of power, I think you will be as interested as I was in a moment's digression to the automobile gas engine. Such engines are usually run at but a fraction of their available power, only a few hours a day, and usually but a few days in the week, so the sum-total of power actually delivered is small compared to the rated horsepower of the

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engines, or the price of gasolene would be higher than it is. When you consider that the total of American automobile engines produced amounts to some 10,000,000 rated horsepower per year, and that one manufacturer is weekly turning out gasolene engines of aggregate power equal to that of some of the largest central stations in this country, the figures for this prime-mover begin to assume significance.

In manufacturing, however, although it is not the only factor we have to deal with, I think we are safe in repeating that we must primarily look to steam generated by burning coal as the power on which to place the main reliance.

In America last year and the two preceding years there was used during each twelve months approximately one half billion tons of coal—the largest part of that coal being used for metallurgy and for power. Last year (1912) the rate of burning coal in this country was almost exactly 1000 tons per minute on a basis of 365 days a year and 24 hours a day. A more striking figure than that is the enormous rate of increase of this use of coal. If we look at the American statistics we find that during the year just passed there was burned about one ninth of all the coal that has been mined since coal mining began, and that during the period from June, 1908, to the present time, there was burned about one quarter of the total coal that has ever been mined.

Now there is no need of the rather hysterical statements that occasionally come from the public press to the effect that the coal is giving out and will shortly leave us stranded—we need anticipate nothing of the kind for a good while yet, but after all the supply is not unlimited, and while the engineer does not desire to shut down plants or reduce the aggregate generation of power, he should strive to get as much power out of each ton of coal as he can. This is not only the duty of the man who wants to make the dollar go as far as he can, but the duty of the man who wants to make a coal-founded civilization go as far as he can.

Now granting this duty of getting as much as we can out of the resources which we have, I do not think that we need criticize the policy or attitude of our forefathers. They came to a country where the resources were many and the means of utilizing them very few. Engineering as a science or an organized art was unheard of. They had only the simplest tools and implements and a slender supply of capital. Their problems were not ours. Their

mills must be kept going regardless of the lesser economies, and even if losses were great, it was good economy to strive for volume and tonnage. These conditions have progressively changed to those we know, and naturally some survivals remain of methods proper to more primitive conditions, but in general intelligent management has dictated a tightening of the lines and a progressively increasing regard for efficiency.

The word "efficiency" has indeed been used throughout the engineering world of late in the specific connections of motion-studies and of the utilization of waste and by-products until it has become almost a by-word, and in following these truly excellent thoughts we must of course be careful that we do not jar ourselves out of one rut into another, and quite sure that proposed economies do not cost directly or indirectly more than they come to.

In considering economy of power, we may divide the situation into two sections having to do with the generation and with the utilization of steam.

As to the generation of steam, it is far from my purpose to say anything since my associate has already shot his bolt. I believe the most of what I know on that subject I learned from him, and as I wish to agree with him on all such matters and I did not hear what he said, I will confine myself to the utilization of steam.

The steam from the boiler goes into the engine room through the usual hole in the wall and in the past, once the plant was built, this hole has been the line of demarkation between large and small possibilities of saving. Up to a very few years ago, about all we could expect in engine-room economy was that the engineer should do his plain duty by the machinery and keep the lubrication up and its cost down. He did not always do this, but when he did not the trouble was plain negligence. But there are a number of other things an engineer can do now besides simply being "on the job," and the most considerable of these things has to do with low-pressure turbines, which in turn have to do with the improvement of existing low efficiency engines rather than with the initial layout of a plant. We need not go very fully into the reason for this just at the present moment, but we may go this far: Power-plant costs are divided into two general classes, the operating costs and the fixed charges; and in laying out a new plant, it is found as a rule that while the operating costs will be a little lower with a combination of the steam engine and low-pressure turbine than with engine

or turbine alone, the fixed charges due to the greater first cost will more than make up this difference. The low-pressure turbine, then, is a machine which is essentially adapted to work in conjunction with apparatus already installed—to increase the existing yield of power rather than to get favorable new yields, so it is proper to consider this machine in the efficiency branch of engineering.

Now let us leave the turbine for a moment and consider some of the questions underlying theoretical economy in the use of steam. The basis of all these is the old formula $\frac{T_1 - T_2}{T_1}$ with which we have all been familiar since college days—the difference in the temperatures at which the prime mover receives and rejects its working fluid, divided by the first temperature.

In order to get a better result in this fundamental formula, that is, to increase theoretic efficiency, here are only two things which we can do; we can increase the initial temperature, or we can lower the final temperature. In order to realize increased actual or practical efficiency we must first establish a theoretical basis of increase and afterward—and equally important—we must take full advantage of the improved possibilities.

Now this extension of theoretical efficiency is accomplished by increasing the initial temperature by working with high pressure steam and with superheat, and by lowering the final temperature by use of high vacuum. We find considerable superheat, and pressures as high as 250 lbs. per square inch, used in reciprocating engines, and they gain marked advantage thereby, but vacuum beyond 26″ for such engines is not as a rule worth the additional cost and trouble which it entails, and it has remained for the turbine to show the way to efficiently realize the enormous theoretical possibilities of high vacuum.

Considering in further detail the relation of the theoretical basis to practical possibilities in the reciprocating engine, we find that the engine is well able to handle superheated steam provided it is properly designed and lubricated, and that some engines in particular handle very high-pressure steam to marked advantage, so the increases in pressure and superheat have resulted about as favorably as would be expected is reciprocating engines. When it comes to realizing on an increase of vacuum beyond the point customary in reciprocating practice, the engine becomes a very

helpless device and nearly all the theoretical gains of efficiency are frittered away in losses peculiar to the reciprocating engine itself. The average engineer who thinks about the matter at all believes that the amount of available energy he is throwing away by expanding down to two pounds absolute pressure instead of a pound, or even half a pound, is relatively small because the pressure differences are small. It is in fact very difficult at first to realize just how large the amount is, but the whole point of the discussion of low-pressure turbines depends upon such a realization, so we may dwell upon it a little. If the energy available from a pound of steam between any two pressures taken as initial and terminal be calculated from the steam tables or from the Mollier diagram, it will be noted that a small pressure range in the regions of low pressure corresponds to as much energy as a very much larger range in the high-pressure region, and in general that the available energy is roughly proportional to the ratio of initial and terminal pressures, regardless of their absolute values. This of course follows from the fact that when pressure is low, volume is correspondingly large, but some of the results are rather striking. We find for instance that very nearly as much energy is theoretically available between atmospheric pressure and commercially obtainable high vacuum, as between ordinary boiler and atmospheric pressures, and that nearly a quarter of the total available energy with usual conditions, is found in the range from 25″ vacuum on down to a really good vacuum. Again expansion of a pound of steam from 26″ vacuum to 28″ liberates substantially as much energy as its expansion from 200 pounds absolute pressure to 100 pounds. In short there is much more energy available in steam from tea-kettle conditions to vacuum than has been generally realized, and this is particularly true of the regions of very low pressure.

In trying to make use of this portion of the available energy designers of reciprocating steam engines at first had no recourse but to use short cut-off in a single large cylinder and to expand the steam as much as practicable in this. With high ratios of expansion and low terminal pressures, the great range of temperature during expansion became so serious a source of loss as to limit progress in this direction. The compound, triple, and quadruple expansion engines improved matters by cutting down the temperature differences in any one cylinder. On the other hand, if we

attempt such expansions as theory shows to be advantageous, it becomes difficult to get the steam into the final cylinder and very difficult to get it out without excessive throttling. About the best that can be done on a triple expansion engine is to use a seven to one ratio between initial and final cylinder volume, and this normally expands down to some four or four and a half pounds absolute exhaust pressure. With a compound engine a four to one cylinder ratio, and release at six pounds absolute is common.

(Here was shown a chart showing a compound engine in Louisville Water Works plant carrying out the idea. Also explained pressure-volume chart.)

Let us further examine the possibilities and limitations of reciprocating engines in this respect. If we expand steam adiabatically from 175 lbs. gauge down to 28″ vacuum figured on 30″ barometer, we shall have an increase of volume to approximately 119 times the initial volume; and expansion to 29″ would about double that figure, making the final volume well over two hundred times the original. Now if we assume a compound engine with a low-pressure cylinder capable of carrying the expansion completely down to 28″ with usual high-pressure cut-off, we find that with 24″ high-pressure cylinder and equal strokes on both, we should have to have approximately a fifteen foot low-pressure cylinder. It is perfectly clear that we cannot use any such cylinder as that,—condensation, and friction, throttling and air leakage into the vacuum would fritter away all the large theoretical gains, even at rated load, and part-load conditions would be worse. Further the construction would be a mechanical monstrosity even if it were desirable otherwise.

Now let us turn from the reciprocating steam engine which we have found is better adapted to deal with steam of high pressure and small volume than with a more attenuated and bulky low pressure working-fluid, and consider the capabilities of the steam turbine in this particular respect. The turbine is no longer the "new baby" in the engineering world, but has become a vigorous youngster. It has passed in a few years from a little known and less trusted machine to one whose characteristics are very well recognized. The steam turbine is well able to take high pressure steam, expand it down to a good vacuum, and use the energy efficiently at all stages of expansion, but turbine designers recognize the fact that rotation losses, bucket losses, leakage, and most of the other detrimental factors incident to turbine design, are the less easy to

deal with and minimize, the higher the steam pressure. With low pressure steam, until the attenuation and the total volume become extreme, there are no difficulties or losses chargeable to the low pressure, and many of those met with higher pressures are minimized, so that the low pressure portion of a complete-expansion turbine is usually more efficient than the high-pressure part. The bulk of the steam entails no such trouble in providing ports and passages as is found with engines, since the normal velocities in the turbine are enormous, and the passages short and simple. The temperature range due to expansion is not objectionable, since any one part is exposed to substantially constant temperature; there are no incidental mechanical losses, the size for a given output is not excessive even when the turbine is designed for 29″ vacuum, and the packings can be, and are, so designed that air leakage into the high vacuum is negligible. The turbine is then a mechanism almost ideally adapted to use low-pressure steam.

We see then that the steam engine is best able to deal with steam of high pressure and low volume, and that the turbine is able to deal with steam of all pressures, but that the efficiency is somewhat greatest in the low-pressure ranges.

That covers the theoretical basis, and we may immediately and properly conclude that if we take high-pressure steam from the boiler to a reciprocating engine and utilize in that the pressure ranges down to approximately atmospheric conditions, and then take it in the form of exhaust from the engine and utilize in a turbine the remaining pressure down to high vacuum, we shall get a unit of extraordinary efficiency. As a general statement, this efficiency if 26″ vacuum or better is available, will be better than can be had from any reciprocating engine, and may be better than that of a complete turbine unit, but will not be enough better than the latter to justify installing the combined unit new unless, as in the case of a rolling mill, the initial unit must be reciprocating. The principal field of low pressure and mixed pressure turbines is therefore the bettering of old plants.

As Professor Sweet has said, so many things do work that should not, and so many things should and do not, that the engineering profession is pardonable for always asking to be shown. We are just passing through the stage of showing the engineer that the turbine is really able to do the things that theory indicates it

should do, and a little later I shall refer to some typical installations.

Now considering the practical form that the low-pressure turbine takes, we may say that while in Europe the design of steam turbines has shown what the biologist would call a wide range of mutations, in America, on account of the concentration of capital and patent rights among a relatively few manufacturers, there are only three or four well known firms who manufacture large steam turbines, and a very few more making small units. The great majority of the low-pressure installations in this country are the product of three makers.

In operation, a low-pressure turbine is merely the low-pressure end of an ordinary turbine; a mixed-pressure turbine is an impulse type low-pressure machine with further provisions for using high-pressure steam direct when necessary. If we consider any of the modern high-pressure steam turbines we find the whole thing admirably simple, compact, and well worked out; in order to make low-pressure turbines, all that it is usually necessary for the manufacturer to do is to eliminate the high-pressure stages, change the governing mechanism somewhat, and pass steam from the exhaust of the engine either directly or through a regenerator, to the low-pressure stages which alone are retained, thus the accumulated experience gained on high-pressure turbines applies directly on the newer low-pressure designs.

The gains in economy which can be realized in cases to which the low-pressure or mixed-pressure turbine is adapted, are quite out of the order of magnitude of ordinary boiler or engine room economies. This matter is referred to later, after specific instances have been cited. In installing this beautiful piece of mechanism, we may assume that we shall have to take some trouble in order to realize best results, but in most cases where it can be used at all, this trouble is not excessive, and centers about governing and condensation.

In the matter of governing, the steam from the engine does not always come in at just the time and in just the amount you want it for the turbine. If the layout of a plant is such that the turbine and engine are each driving electric generators which operate in parallel, we have an ideal condition in this respect, and have the equivalent of a compound or a triple expansion engine

of which the turbine constitutes a phenomenally efficient low-pressure cylinder.

When the engine runs on one load and the turbine on another, the engine may at any moment be delivering a certain amount of steam with the turbine at the same moment demanding a greaer or a less amount. It is usual in such cases either to install a mixed-pressure turbine, or a reduced live-steam supply to the low-pressure machine, or else to pass the steam from the engine into what is known as an accumulator or regenerator where the steam bubbles though a large body of hot water on its way to the turbine.

With a regenerator installed, if the turbine is not using all the steam that the engine in delivering, then the regenerator pressure rises slightly, the excess steam condenses, the water is heated, and the level of the stored hot water rises, so that there is storage of energy due both to the increased temperature of all the hot water, and to the added amount of water. If the steam is not passed in as fast as required then the regenerator pressure and temperature go down slightly and some of the water is boiled off, thus making up the deficiency of supply for a limited time. If the plant is laid out as is customary, the regenerator alone will supply the low-pressure turbine from two to five minutes.

When the steam from the engine is insufficient in quantity for a period longer than can be bridged by the regenerator, live steam is admitted directly to the turbine either through separate nozzles in mixed-pressure designs or through a reducing valve in straight low-pressure and works substantially as it would in the ordinary high-pressure turbine. As I have indicated before, many plants in this country dispense with regenerators which are rather expensive in first cost, and use live steam to make up all deficiencies whether brief or extended.

There is another excellent method of governing for those cases where the engine is operated on mechanical or independent electrical load; in this the turbine generator is electrically paralleled to a synchronous motor, which may act either as a motor or a generator, belted or otherwise connected to the engine. If the turbine is carrying more than its share of the load, this machine belted to the engine shaft becomes a generator and helps to carry the load of the turbine at the expense of the engine. This also causes the engine to require more steam, which it delivers to the turbine, thus further equalizing the division. If the turbine is getting from

the engine more steam than its load requires, it delivers current to, and drives, the synchronous motor, thus directly helping the engine and also choking down its own excessive steam supply by reducing the engine load. There are other special methods of governing applying to special cases.

The question of condensation is one of paramount importance in determining whether it will pay to put in a low-pressure turbine.

Of course if steam is taken at about atmospheric pressure we have only fifteen pounds or somewhat less as the available range of pressure to work on between that and the barometric vacuum, and it is clear that we shall have to get a good vacuum or the pressure range will become too small to give satisfactory results. In general a low-pressure turbine should not be considered unless there is means for reliably getting a 25″ vacuum at least, and it is hardly worth while unless the vacuum is rather better than that. Fortunately cases are rare when it is not possible to get at least 27″ with cooling towers, even in the absence of a plentiful supply of condensing water, and the development of cooling towers has materially extended the field of usefulness of low pressure turbines.

In one plant where two low-pressure turbines were installed paralleling street railway engine units, there was an interesting illustrative incident. This was a pioneer installation, and one of the operating engineers feared that with nothing better than cooling-tower vacuum the turbines would require more initial pressure than was figured, and would increase the back-pressure on the engines, so to meet his objection the engine exhaust pipe on the top of the building was left wide open to the atmosphere, while the turbines drew their supply from a point near its base. This proved to the engineer in a graphic manner that he was not getting increased back pressure and that the turbines were really taking their steam at atmospheric pressure. This station was able to maintain a 28″ vacuum by means of cooling towers on the roof with no source of cooling water other than the Philadelphia city supply, and the economies have been all that had been hoped for. Since low-pressure turbines have received recognition, a large number of plants have put in such towers with uniformly favorable results.

There are many low and mixed pressure turbine units now in successful operation, and brief reference to a few typical stations may be useful.

The Interborough station at 59th Street, New York, is one

of the best known examples. This station was originally equipped with nine Manhattan type engines each consisting of a vertical and a horizontal cylinder, high and low pressure respectively, driving on the same crank and each delivering a maximum of 8000 H.P. with rated load based on economical performance of about 5000 H.P. The steam economy at maximum load was poor and the boilers were unable to furnish sufficient steam for the increasing peak. It had become imperative to do something, and the only practicable courses were either to make a comprehensive redesign or to put alongside of each engine a low-pressure turbine unit taking steam from the engine, and delivering current in parallel with the engine-driven generator. The low-pressure turbines were installed. They are vertical units driving generators of the inductor type having squirrel cage rotors, and are run in parallel with the engine at all times, taking what steam the engine is giving and delivering into the busbars a corresponding amount of electrical energy. The economy of the combined unit over extreme ranges of load is very striking (here were shown figures illustrating) and the result has been some 25% fuel saving as compared with previous conditions, an increase of 100% in maximum load capacity (involving some changes in the old boilers, but no new ones) an increase of 146% in economical capacity of the plant, and a station which is giving a kilowatt-hour at terminals over a wide range of loads, for each 13¼ pounds of dry saturated steam, an economy which is as favorable as that of any other station in the country.

(Here read from engineer's paper regarding curves.)

This paper gives the water rate figures, and shows particularly strikingly by plotted curves (Series E, F, pages 355 and 356) that the amount of steam per KW. hour (not H.P. hour) for loads ranging from 7000 KW. to 15,000 KW. at no time exceeds 13¾ pounds.

Under moderate and high loads the turbine carries roughly from three quarters to nine tenths as much load as the engine. The exact figures together with much further interesting data are given in this well known paper, presented by Messrs. Stott & Piggott before the joint meeting of the Mechanical and Electrical Engineers on March 8th, 1910.

While the 59th Street station possibly furnishes the best known example of the advantage to be gained by use of low-pressure turbines under ordinary central station conditions, there are a

number of other instances of unusual interest. A very large unit is operated in parallel with engines in Philadelphia under conditions similar to 59th Street, and many other smaller installations of this kind might be listed.

A 1500 KW. mixed pressure unit at the Youngstown Sheet & Tube Company's mill is typical of plants using regenerator, and taking steam from intermittent sources—in this case rolling mill engines. The fact that the generator in this case parallels several generators driven from high-pressure turbines gives rise to some very pretty governing problems.

The largest low-pressure turbine thus far attempted is soon to be started by the Calumet & Hecla Company. This uses steam, formerly wasted, from four hundred steam stamps. A regenerator equipment is used. The turbine is of 12,500 kilowatt capacity and the unit furnishes light and power for general purposes.

A 6000 horsepower low-pressure turbine operating a blower for blast furnaces constitutes a unit of unusual interest, of which you will probably soon hear, and there are some excellent examples in Europe.

Finally comes the large and increasing number of smaller units in all sorts of industries—not a few in chemical plants—representing aggregate savings of fuel which are hard to realize.

Now a word on the conditions under which a low or mixed pressure turbine may be expected to show satisfactory savings.

There are of course many cases where exhaust steam is used for heating in the course of manufacturing processes or for heating buildings. In general it will not pay to put in a low-pressure turbine for utilizing heating steam during the warm months, and obviously the same consideration applies where steam is used in manufacturing processes. There are exceptional cases in which steam for processes must be exhausted above or near atmospheric pressure, as for example in certain forms of vulcanizer, and if the amount involved is sufficiently large it may be possible to use it with advantage—indeed I have in mind an installation of this kind. In most cases, however, the use of steam for heating involves its condensation and the consequent return of the specific heat of vaporization, and if the heating must be done, and can be accomplished with exhaust steam, there is no better use to which it can be applied.

Where there is an available supply of exhaust steam which

is not needed for heating, or where there is an existing reciprocating engine plant and at the same time use for further power, there are still several questions to be answered.

First, as already pointed out, a fairly good vacuum is necessary in order that a low-pressure turbine shall have a sufficient working range. As a rule a sufficient vacuum can be obtained by cooling ponds with sprays or by cooling towers, even when a large water supply is not accessible, but a good supply of cool condensing water is naturally to be preferred.

The relation between the exhaust steam supply and the added load requirements is of manifest importance. The low-pressure turbine in common with other turbines has at present a relatively limited range of adaptabilities in the matter of driven machinery. It is nearly always employed to drive an electric generator, but it is also adapted to driving blowers of large capacity and relatively high pressure, and high pressure centrifugal pumps. The development of gearing suited to heavy work and high speeds will probably increase this range of aptitudes very materially in the near future.

While the steam regenerator will bridge over the brief deficiencies of steam supply and store up brief excess amounts, and while a mixed-pressure turbine, or in less degree a low-pressure turbine with reduced live steam supply, will operate on boiler steam when no exhaust is available, it is nevertheless necessary that a sufficient supply of exhaust steam should be delivered without serious interruption during all or nearly all of the time that the turbine requires it or the net saving will be materially lessened. When both engine and turbine are working on the same load or the same kind of load, this condition will usually be met. On the other hand when the loads are unrelated, for example, when the engines are running a rolling mill and the turbine is run on power and lighting load, a careful preliminary study of this point becomes an important matter.

Assuming these points to be settled and the added power represented by the proposed turbine to be required, the next question is whether existing engines should be taken out and replaced by completely new equipment of modern form, as for example new complete expansion turbines, or whether they should be retained and reinforced by low-pressure turbine. Of course each case is a special one, but it may be said in general that if the engines are in reasonably good condition and their efficiency is either tolerably satisfactory or is unsatisfactory through over-load and not through

general decrepitude, the low-pressure turbine is indicated. When low-pressure turbines were first proposed it was not thought they would find application much beyond the cases where existing engines were running non-condensing. In such cases the steam which was being exhausted to the atmosphere represented a dead loss which these turbines were well adapted to turn into useful revenue. Later experience has gone to show that the turbine makes so much more efficient use of the steam in its lower pressure ranges that it is very often worth while to install such a unit in connection with engines formerly run condensing, and even with compound engines so run. In such cases the engine is deprived of the use of the steam from about atmospheric pressure on down to condenser pressure and suffers in economy thereby, but the turbine to which this steam is given is able to do so much more with it than the engine had previously done that the net gain is sufficient to amply justify the investment in a large number of cases. Speaking from memory I should say that there are many more low-pressure installations in New England in which the engine had formerly been run condensing than those in which the reverse was true. In this connection it should be remembered that the most economical load point of a given engine is at a higher load on non-condensing than on condensing operation, so the change of operating conditions just referred to does not reduce the maximum engine load, although it does reduce the economy of the engine taken alone.

As already pointed out, it is very rarely good engineering to install an engine and a low-pressure turbine instead of one or more complete expansion turbines in a new plant. The engine-turbine combination will usually give a little better economy than the turbine alone and considerably better than an engine alone, but the increased fixed charges due to higher first cost will usually more than eat up the slight decrease in operating expenses.

As to the magnitude of the savings, it is very difficult to generalize, and you will quite appreciate I am sure that the generalizations that I am about to make are subject to many reservations.

Where an existing engine is exhausting to the atmosphere, is fully loaded or over-loaded, and is in fair condition, where 28″ vacuum of better can be obtained, and where load conditions are such that the turbine can continuously deliver all the load that it receives steam for, it will usually be found that the amount of coal burned per total horsepower delivered can be cut in two by installing a low-

pressure turbine. This ideal case is of course not very often met with.

Where the engine has been running condensing and the load conditions are favorable, the coal burned per horsepower delivered will usually be reduced to a figure approximating two-thirds or three-fourths of the previous amount.

Various departures from favorable conditions of steam supply and load may reduce these savings by varying amounts and each case should of course be carefully studied. It is perfectly conservative, however, to say that there is a very large number of plants now operating where a suitable low-pressure turbine would pay for itself in from one to three years.

In summation, we have seen that there are simple and sufficient theoretical reasons why a turbine can get more power out of low pressure steam than an engine can, that there are on the market turbines of several types and a wide range of sizes which approach these theoretical possibilities and that the country is dotted with plants where the judicious installation of such turbines would affect greater economies of power than would anything else that could be done. If we are right in these statements, and there seems to be no doubt on the point, we may expect to see the low-pressure turbine come into rapidly increasing prominence as a means of increasing the efficiency of existing power plants.

DISCUSSION.

Dr. WAGNER: I beg to thank you for the members for your kindness in presenting your paper and beg to assure you that we appreciate very much the interesting data submitted, particularly your final remarks about the efficiency of the low-pressure turbine used in connection with the steam engine so far as the reduction of coal consumed is concerned.

I would be glad if the members of the Institute would start a discussion.

Mr. HOWARD: I would like you to say a few words about producing this very high vacuum with different types of condensers.

Mr. CALLEN: It depends quite a lot on the local conditions. A surface condenser brings pure water to the boiler and also minimizes the air to be removed by the air pump. With the low-pressure turbine the first advantage may be nullified because the feed water has

already become contaminated by the reciprocating engine, and the second rendered unnecessary by the remarkably effective new forms of air pump.

The surface condenser is to my mind justified only in case feed water is bad or expensive, and conditions are such that it gives sufficiently pure condensed water for the boiler. In the case of the 59th Street station the steam on the way from the engines to the turbines is passed through a very effective oil separator and the oil in the feed water kept down to four grains per gallon, which is found sufficiently good for all purposes. The steam is passed from the separator to the low-pressure turbine and then to a surface condenser and returned to the boiler. If the condensed water is not to be used as boiler feed, the newer special forms of jet and barometric condensers have simplicity and freedom from repairs to recommend them. Some of these new forms, such as the Le Blanc, in which air is driven out by a broken column of water from a high-speed centrifugal pump, appeal rather strongly to me. This type has been used rather widely of late with admirable results. Some of the best barometric condensers and the so-called "rain type" condensers give good results. The problem centers more or less about getting out the highly attenuated air, most of which enters with the condensing water.

Mr. HOWARD: How much does the pump require for a Le Blanc condenser?

Mr. CALLEN: The power, expressed as a percentage of full turbine load, varies a good deal with local conditions, but it is usually a little higher than with most of the other forms; but if a given condenser gives even 0.1 or 0.2 inch better vacuum than could otherwise be realized, this will furnish all the additional power. That would not be true on an engine but is on the turbine. But very little addition of vacuum on a turbine makes the power go up surprisingly.

IMPORT DUTIES ON CHEMICALS, AND THEIR INFLUENCE ON THE CHEMICAL INDUSTRIES

By F. W. FRERICHS

Read at the Boston Meeting, June 27, 1913.

The pending tariff legislation necessarily directs our attention to speculations as to the possible influence it may exert upon the industry which we represent.

Tariff revisions in the past always have given cause for grave apprehension, and especially has this been the case, whenever the revision was coincident with a change of policy in the Government, as in 1894, when the last Democratic tariff bill was inaugurated. At that time the apprehension was especially keen because revision followed closely upon the crisis of 1893, when the entire business activity of the United States was more or less paralyzed by an unfortunate coincidence of conditions. The tariff revision of 1894 found the chemical industry in the United States in a weak condition. Only partly developed under the moderate protection offered by the tariff bills of 1866 and 1883 it had received a mighty impetus by the more protective McKinley bill of 1890. Much capital had been invested under the protection of this law, but much of it had not yet brought returns when protection was withdrawn by the Wilson bill, which became a law August 27, 1894 without the signature of the President of the United States. It was a Democratic measure with greatly reduced rates, injudiciously designed, unfair to all, and brought disaster to the industries of the entire country, and to the party which inaugurated it. Only when the Dingley tariff bill of 1897, quietly prepared during the last months of Cleveland's second administration was made a law July 24, 1897, did conditions assume a brighter aspect, and many investments made under the McKinley act could be saved which were already considered lost under the Wilson tariff bill.

The Payne tariff of 1909 changed the chemical schedule very little, and from 1897 until now the entire industry of the United States has had fifteen years of unprecedented prosperity, in which labor as well as capital fairly participated. True, chemicals were not exceptionally highly protected, but by the large demand for them, created by the flourishing conditions of the other industries, chemical manufacturers received their share of profits and participated in the prosperity of the entire country. Large chemical plants have been established during this time and many old and obsolete plants have been rebuilt on modern lines. But the most important fact is that the investment has brought returns and is largely paid for by profits made in a series of prosperous years. Especially the manufacture of heavy chemicals, like acids, alkalies, paper pulp and cement, have grown to such proportions that profits could be reduced to a minimum, without losing a fair return on the investment. Selling prices of chemicals have been greatly reduced by competition, independent of tariff protection, so that the staples can be bought to-day for much less money than they were bought for fifteen years ago. The public as well as the manufacturer has been the gainer, and the laborer has enjoyed steady work at good wages, and has prospered too.

In many cases, tariff protection has become less necessary, and there is now little protest against a reduction of tariff rates, if the reductions are made in a judicious and reasonable way.

To-day, there is no danger that the larger chemical industries will be seriously impaired by changes of import duties. They are strong in capital, are accustomed to fair profits, and are not inclined to cut prices for the sole purpose of showing sales. In many instances there are natural advantages which secure the home market and keep out foreign competition. I refer to the cheap coal and to the abundance of mineral deposits, which make by-product coke ovens and fertilizer works firmly established industries. There are furthermore, the natural products of the soil which command a continuous market for corn products, distilleries, and the products of wood distillation. There are the animal industries which will keep in this country the manufactures of glue, glycerine and soap. There are finally the costs and dangers connected with transportation which will always make the manufacture of heavy chemicals and explosives profitable in this country and to a great extent independent of tariff protection.

But there are many of the smaller chemicals, the manufacture of which in this country may suffer if the import duties which affect them are regulated in an injudicious manner.

The changes which the Underwood bill proposes in the existing tariff act and particularly the arguments which are brought forward to support these changes are radically different from the views which guided former tariff legislation by the Republican Party. In framing the traiff laws of 1897 and 1909 it was the avowed purpose of Congress to devise bills which provide for the revenue of the Government and which at the same time would protect and encourage the industries of the United States. While the tariff duties imposed by former acts were of such a nature that many industries were actually protected, the bill as proposed by Mr. Underwood is decidedly nonprotective. It reduces the import duties in many instances. It puts many dutiable articles on the free list and it imposes import duties on a number of raw materials which are not found in the United States and which have to be imported from other countries for use in American manufactures. As an explanation it is pointed out in a report which accompanies the Bill that the tariff is not intended to be protective since the Committee on Ways and Means is of the opinion that the American industries have sufficient strength to hold their own as against foreign competition. It is contended that our industries are in many instances favored by abundance of cheap raw material, by extended markets among the home population and that they also are protected by the freights and expenses which necessarily are connected with the importation of goods from other countries. For these reasons the Committee considers itself justified in disregarding the interests of home industries and present a schedule principally for the purpose of providing revenue for the National Government. They go even further by putting certain chemicals on the free list, favoring, for instance, the paper, cotton and woolen mills, thus injuring the interests of chemical manufactures for the purpose of favoring other industries. In framing former tariff acts it had been deemed wise to admit free of duty from foreign countries partly finished products, which could not be used directly in the arts but which were necessary for the production of finished chemicals and to impose duties on the finished articles. I refer to the great number of coal tar preparations, which were enumerated in paragraph 536 of the free list

of 1897 and 1909 and which includes products of coal tar known as dead or creosote oil, benzol, toluol, naphtalin, xylol, phenol, cresol, toluidine, xylidin, cumidin, nitrotoluol, dinitrobenzol, benzidin, dianisidin, naphtol, naphtylamin, diphenylamin, benzaldehyde, benzyl chloride, resorcin, nitro-benzol, naphtylaminsulfoacids and their sodium or potassium salts, naphtolsolfoacids and their sodium or potassium salts, amidonaphtolsulfoacids and their sodium or potassium salts, amidosalicylic acid, dinitrochlorbenzol, diamidostilbendisulfoacid, metanilic acid, paranitranilin, dimethylanilin; all the foregoing if not medicinal and not colors or dyes. These and some other chemicals like anilin and its salts were put on the free list, for the purpose of drawing gradually to this country the more complicated manufactures of artificial perfumes, medicinal preparations and coal tar dyes.

The wisdom of this measure is apparent by the fact that under its protection quite a number of places of manufacture in this line have been established. The measure was particularly pleasing to the chemists since these industries are most fascinating, giving to the best trained chemists congenial and profitable work.

The measure was pleasing also to the universities since it gave to them opportunity for training students in most advanced chemical research.

Indirectly this state of affairs had a beneficial influence on the development of kindred chemical industries since many chemists who prepared themselves by scientific research drifted into other lines of manufacture, carrying into these industries a grade of training which they otherwise might not have acquired.

Incidentally, the community at large was compensated by the cheapening of prices for many articles, the manufacture of which was undertaken in the United States. Instances of this kind are the reduction in price of salicylic acid which under American competition fell from $1.25 to 35c.; of synthetic oil of wintergreen, which was reduced from $1.25 to 40c.; of acetanilid which was reduced from 50c. to 25c.; of phenolphtalein which sells now at $1.20 instead of $2.15, and many others.

The diffusion of chemical knowledge helped the community to see that they could buy acetanilid for 30c. while they paid $1.00 for antifebrin and if the patents for aspirin have expired people will readily understand that one ounce acetylsalicylic acid for five cents is the same as one ounce aspirin for forty-three cents.

By the new law it is proposed to transfer the coal tar preparations enumerated in paragraph 536 of the present free list to the dutiable list at 10% and in addition to this it is proposed to admit many of the finished preparations derived from them at a duty of 15%, while formerly they were admitted at 25%.

You will readily understand that a great part of the investment in the manufacture of these articles will be lost if the tariff is changed as proposed by the Party in power and that many of the best trained chemists and many laborers will find themselves out of work. Whatever progress has been made in this direction would be paralyzed or greatly retarded if these industries were made impossible by tariff act. I cannot help thinking that the encouragement given to work in these lines has been well worth the sacrifice of any revenue which might have been derived from the importation of such goods. Moreover it would seem doubtful whether they could be profitably imported if a duty is imposed on them, in which case the desired object of obtaining revenue from them would not be attained.

In the interest of science and education to which synthetic chemical manufactures mean so much, it would seem most desirable that free entry of articles enumerated in paragraph 536 of the Payne Law be continued, and that the tariff on finished products which are made from them remain 25%.

It is commonly conceded that the present tariff contains gross inequalities which have in many instances enriched a few at the expense of the community at large. To remove such inequalities there certainly is no objection on the part of any fair minded man.

But to go beyond this and to abolish in an injudicious way and without warning moderate protection to a great number of the smaller chemical industries would seem reckless and can only work harm to the country and to the Party, which is responsible for such action.

The present state of affairs has been created by a number of successive administrations and a large number of manufacturing plants have been erected at great outlay of money much of which will be lost if protection is suddenly withdrawn. If a change is desired it would seem to be the duty of a wise Government to bring it about gradually in order to minimize unavoidable losses in investments and to give time to manufacturers to adjust themselves to changed conditions.

Import duties are levied for the purpose of providing revenue for the Government or for the protection of home industries or for both.

Whether the one or the other purpose is prevalent is indicated by the rate of duty which is imposed upon the various articles of importation.

Since every Government regulates the import duties for the country it represents it is natural that they be adjusted for the best of the people which is represented by the Government.

In so large and well developed a commonwealth as the United States a great variety of industries is represented and it would seem to be the duty of those entrusted with framing the tariff schedules to adjust them so that burdens and benefits are justly distributed. To arrive at a just distribution the following chain of reasoning may be construed.

Our natural resources are our soil, our waters and our mines. What we derive from them by our work serves to provide for the necessities and luxuies of life.

What we derive in excess is our wealth.

The efficiency of our efforts is increased by a division of work.

The tiller of the soil and the fishermen can provide many times more food stuffs than they need for themselves, while the miner produces values which may represent accumulated wealth.

They all have a natural desire for luxuries, the manufacture of which necessitates training which neither of them can acquire.

If they all form one community or commonwealth by interchange of their products each member can participate in whatever the other has in abundance and each can have in a measure necessities and luxuries of life.

The basis of interchange of goods is their value which should be such that all can enjoy the necessities and luxuries of life in proportion to the work which they have done in their own vocation.

The value of work is measured by the amount of money which the individual can earn in the unit of time.

The simplest form of a commonwealth would be one in which all the products derived from natural resources and all the products derived from manufactures are utilized by members of the same community.

Such, however, is rarely the case. The modern methods of

transportation facilitate exchange of goods and manufactures between the many commonwealths of the world.

Goods are products of natural resources made available by work of men. Such goods may be enhanced in value by additional work and may become the carriers of labor from commonwealth to commonwealth.

The value of natural resources is measured by the value of goods obtained from them, less the cost connected with their working and transportation to places of consumption. It is independent of time, and the value of the goods is relatively independent of later or earlier consumption.

The value of labor includes the cost of living of the laborer and is dependent upon time.

The values of both goods and labor are dependent upon supply and demand but labor is much more so since it is also dependent on time and must be utilized continuously or else it is lost.

By the value of labor a standard of living is established which varies widely in various communities. Admittedly, both are among the highest in the United States, where the wages are such, that a large measure of luxuries can be enjoyed by the wage earner, who, in addition, can accumulate some wealth.

If these condtions are to continue it is necessary to restrict the importation of manufactured goods from countries where labor is cheaper, by imposing a duty on their import.

Such duty should be commensurate with the higher cost of production, based upon the standard of living in this country. It should equalize the cost of production from resources abundantly offered in this country but it should not enhance the value of the resources themselves nor should it attempt to create resources which the country does not possess.

It should be considered that the cost of production varies often in different sections of the same commonwealth and the rate of import duty should equalize the cost of production between the most favored place of production abroad and a fair average cost of production at home.

A schedule of import duties based on these principles must certainly find universal approval.

But to apply these principles throughout the schedule requires intimate knowledge of prevailing conditions in our own and in other commonwealths.

It is unfortunate for the American people that no such equitable schedule has been designed. By past tariff laws we have been ground between two opposing mill stones, represented on the one side by free trade and on the other by ultra high protection and by sudden changes from one system to the other so that the country has been repeatedly thrown into convulsions which have greatly retarded its steady progress.

Sugar is one of the articles which was protected by a high duty for a long period of time. Under this protection sugar cane is grown at a moderate profit in sub-tropical sections of the United States while it is a tropical plant. It requires for full growth fifteen to twenty months and cannot stand any frost.

In Louisiana the frost free period of a year does not exceed ten months and the cane must be cut before it is ripe, yielding less than half the amount per acre obtained in tropical countries, while the amount of work per acre required for planting and cutting is the same.

On account of climatic conditions Louisiana would seem unable to compete with tropical countries in raising sugar cane.

A small duty on sugar equalizing the value of work connected with its production may be justified but if with such protection sugar cane cannot be raised profitably in Louisiana it should be abandoned.

The condition in Porto Rico is different. In this island the climatic conditions are as favorable as anywhere and a small import duty commensurate with better paid labor will enable the islanders to compete successfully in the production of sugar cane. Their pleading for protection would seem to be less reasonable than Louisiana's.

As a matter of fact the sugar industry is flourishing in Porto Rico some of the mills paying 100% dividends on the capital stock per year.

Gold and silver are free of import duty and gold and silver mines are not considered workable if they are not rich enough to pay for the higher cost of mining in our States. Why should lead be protected to the amount of 100% while copper is free? A reduction of the tariff rate from 2⅛c. to ½c. per pound as proposed is certainly justified. Our mines are so rich that producers in the West pay exorbitant salaries to their officers to show less profits.

From the hearings we learn that white lead is sold in London by American manufacturers at four cents a pound, while in the United States they charge seven cents. The proposed reduction of import duty from 2½c. to 25% would seem fair and even a further reduction would seem justified.

Many goods have a natural protection on account of their low value and great weight or bulk. A low rate of import duty or even free entry seems therefore justified. Many goods of this character are justly on the free list of the tariff of 1909 as for instance, clay, manganese ore, phosphate rock, petroleum, coal tar, and others like coal, beauxite, charcoal, soda ash, salt, sulphur and salt cake should rightly go there, since the labor stored in them is amply protected by cost of transportation from foreign ports.

Other goods are naturally protected on account of the risk and difficulty connected with their transportation, like muriatic, nitric and sulphuric acids and bromine, which are justly put on the free list.

There may be a question whether such goods should be made dutiable which are produced in the United States as by-products in excess of domestic consumption and which are often exported at a lower price than is charged for them in the home market. Such are wood alcohol and acetate of lime.

But it cannot be readily understood why highly finished chemicals like phosphorus, santonine salts and strychnine should go on the free list.

Particularly is it regretted that the finer chemical industries are to be deprived of protection, whereby progress of chemistry as a science would seem to be impaired.

On the other hand many favors seem to be shown in the Underwood bill by increasing import duties on many chemicals, ostensibly for the purpose of securing revenue.

Taking the tariff situation as a whole, there seems to be a desire for judicious legislation. This would seem to be natural since life or death of the Party in Power largely depends upon the success of the Law. But it is apparent that the Senate as well as the House of Representatives is insufficiently advised in regard to the Chemical Schedule which by its very nature requires more than any other schedule the painstaking labors and detail work of a permanent tariff board.

THE DRYING OF LINSEED OIL WITH RED LEAD AND WHITE LEAD

By J. C. OLSEN and A. H. CALLAGHAN

Read at the Boston Meeting, June 27, 1913.

This investigation is a continuation of the investigation on the oxidation of linseed oil which was read at the Eighth International Congress of Applied Chemistry, held in New York, September, 1912, and published in the Proceedings of this Congress and also in the Fifth Volume of the Transactions of the American Institute of Chemical Engineers. That investigation was carried on for the purpose of ascertaining the amount of water and carbon dioxide which was given off during the drying of pure linseed oil to which neither any dryer nor pigment had been added. A very large amount of both water and carbon dioxide was given off, as well as a volatile product which blackened the concentrated sulphuric acid in which the water is absorbed. The total amount of oxygen absorbed was found to be very much greater than had been supposed from the results obtained by noting the increase in weight of the oil. Inasmuch as there was a very considerable loss of water and carbon dioxide, the increase in weight of the oil would not give the amount of oxygen which was absorbed during the drying process.

The present investigation was undertaken to ascertain the amount and rate of absorption of oxygen, as well as the evolution of water and carbon dioxide when the linseed oil was mixed with paint pigments. A portion of the sample of linseed oil used in the preceding experiments was used and is a portion of the sample taken by the American Society of Testing Materials, which was pressed by the National Lead Company at their Atlantic branch, Brooklyn, N. Y., February 2, 1909 and bottled under the direction of G. W. Thompson. The pigments experimented with were red lead and white lead. The red lead was obtained from the National Lead Company and contained, by their analysis, 93.42%

of true red lead (Pb_3O_4) 2.186% available oxygen, and all but .04% was fine enough to pass through a No. 21 silk bolting cloth.

The white lead used was part of a sample taken by Committee D 1 of the American Society of Testing Materials. It was of the following composition by analysis of the Bureau of Chemistry and Bureau of Standards in Washington.

Carbon dioxide	11.75%
Water	2.30% (2.04% combined, .26% moisture)
Lead Oxide	85.00%
	99.05%

It was calculated to contain 71.0% $PbCO_3$ and 27.1% $Pb(OH)_2$.

The experiment was carried out in the same manner as employed with the pure linseed oil, that is, the apparatus consisted of a soda lime tube, a Geissler caustic potash bulb and two tubes containing concentrated sulphuric acid. The air passed over the linseed oil was purified by passing through this train of apparatus, removing all carbon dioxide or acid gases as well as moisture.

The linseed oil with the red lead or white lead was placed in a dry weighed flask of 300 c.c. capacity. A two hole rubber stopper was inserted in the flask and a tube conveying the purified air extended to the bottom of the flask. The air was drawn out through a short tube and was drawn through a U-tube, containing concentrated sulphuric acid, then a Geissler caustic potash bulb, followed by a weighed U-tube, containing concentrated sulphuric acid, beyond which a guard tube containing calcium chloride and an aspirator was placed.

Four liters of air were drawn through daily. Daily weighings were made of the various absorption tubes and also of the flask containing the linseed oil with the pigment. Before placing the oil with the pigment in the flask, the apparatus was tested for leaks and air drawn through for several weeks until the absorption train had come to constant weight.

One hundred parts by weight of the red lead were mixed with 25 parts of oil which is the proportion of this pigment which is ordinarily used. The method of mixing and introducing the paint into the flask was as follows: Into the dried weighed flask the oil was first introduced and then weighed. A weighed amount of the pigment was then added and the constituents mixed by shaking the

flask until a smooth mass was obtained, which was distributed as evenly as possible over the walls of the flask. A weighed amount of dried glass wool was then introduced to soak up the excess and prevent a large quantity of paint from settling to the bottom. The glass wool also provided a larger surface of contact of the paint with the air. In this manner, absolutely known amounts of

TABLE I

DAILY CHANGES IN WEIGHT OF OIL AND RED LEAD

Day.	Increase in Weight of Flask. Gr.	Weight of H_2O Evolved in Grams.	Weight of CO_2 Evolved in Grams.	Total Oxygen Absorbed in Grams.
1	.0218	.0064	.0030	.0312
2	.0530	.0040	.0015	.0585
3	.0875	.0041	.0037	.0953
4	.0384	.0014	.0030	.0428
5	.0437	.0105	.0086	.0628
6	.0441	.0108	.0063	.0612
7	.0247	.0110	.0070	.0427
8	.0124	.0091	.0082	.0297
9	.0098	.0097	.0063	.0258
10	.0124	.0057	.0045	.0226
11	.0125	.0058	.0045	.0228
12	.0046	.0056	.0021	.0123
13	.0013	.0058	.0055	.0126
14	.0015	.0059	.0075	.0149
15	.0027	.0035	.0048	.0110
16	.0024	.0034	.0017	.0075
17	.0020	.0035	.0016	.0071
18	.0214*	.0048	.0048	.0118*
19	.0024*	.0106	.0053	.0135
20	.0075*	.0058	.0042	.0025
21	.0193	.0075	.0047	.0315
22	.0001	.0042	.0018	.0061
23	.0100*	.0031	.0029	.0040*
24	.0105*	.0032	.0030	.0043*
25	.0033	.0064	.0033	.0130
26	.0047	.0040	.0038	.0125
27	.0025	.0034	.0038	.0097
28	.0000	.0055	.0045	.0100
29	.0009	.0050	.0047	.0106
30	.0111	.0044	.0048	.0203
36	.0038*	.0085	.0046	.0093
43	.0091	.0210	.0075	.0376
53	.0040	.0082	.0029	.0151

* Indicates decrease.

oil and pigment were introduced. All weighings of the flask were made, using another flask of the same size and shape as a counterpoise to avoid errors due to contamination of the surface with moisture and other gases. 5.0149 grams of oil were used and 20.0403 grams of red lead. Weighings were taken, extending over a period of 53 days, when the change in weight had become very slight. The color of the paint changed slightly during the run,

TABLE II

TOTAL GAIN IN WEIGHT EACH DAY FOR OIL AND RED LEAD

Day.	Total Gain in Weight of Flask. Grams.	Total Gain Water in Grams.	Total Gain CO_2 in Grams.	Total Oxygen Absorbed in Grams.
1	.0218	.0064	.0030	.0312
2	.0748	.0104	.0045	.0897
3	.1623	.0145	.0082	.1850
4	.2007	.0159	.0112	.2278
5	.2444	.0264	.0198	.2906
6	.2885	.0372	.0261	.3518
7	.3132	.0482	.0331	.3945
8	.3256	.0573	.0413	.4242
9	.3354	.0670	.0476	.4500
10	.3478	.0727	.0521	.4726
11	.2603	.0785	.0566	.4954
12	.3649	.0841	.0587	.5077
13	.3662	.0899	.0642	.5203
14	.3677	.0958	.0717	.5352
15	.3704	.0993	.0765	.5462
16	.3728	.1027	.0782	.5537
17	.3748	.1062	.0798	.5608
18	.3534	.1110	.0846	.5490
19	.3510	.1216	.0899	.5625
20	.3435	.1274	.0941	.5650
21	.3628	.1349	.0988	.5965
22	.3629	.1391	.1006	.6026
23	.3529	.1422	.1035	.5986
24	.3424	.1454	.1065	.5943
25	.3457	.1518	.1098	.6073
26	.3504	.1558	.1136	.6198
27	.3529	.1592	.1174	.6295
28	.3529	.1647	.1219	.6395
29	.3538	.1697	.1266	.6501
30	.3649	.1741	.1314	.6704
36	.3611	.1826	.1360	.6797
43	.3702	.2036	.1435	.7173
53	.3742	.2118	.1464	.7324

becoming somewhat lighter in color. The concentrated sulphuric acid darkened, becoming slightly brown on the 3rd day, amber color on the 9th day, and dark brown on the 15th. The color did not deepen during the remainder of the run. The acid tube following the caustic potash bulb remained unchanged. The results are given in Table I which gives the daily changes in weight of the oil and the red lead, and the water and carbon dioxide

TABLE III

TOTAL GAINS EACH DAY BY PERCENTAGE, OIL AND RED LEAD

Day.	Increase in Weight of Oil, Per cent.	H_2O evolved, Per cent.	CO_2 evolved.	Total oxygen Absorbed, Per cent
1	.43	.12	.06	.62
2	1.49	.24	.09	1.82
3	3.24	.29	.16	3.69
4	3.99	32	.22	4.53
5	4.88	.53	.40	5.81
6	5.75	.74	.52	7.01
7	6.24	.96	.66	7.86
8	6.49	1.14	.82	8.45
9	6.70	1.34	.95	8.99
10	6.93	1.45	1.04	9.42
11	7.19	1.56	1.13	9.88
12	7.30	1.68	1.17	10.15
13	7.32	1.79	1.28	10.39
14	7.34	1.91	1.43	10.68
15	7.38	1.98	1.52	10.88
16	7.44	2.05	1.56	11.05
17	7.48	2.12	1.59	11.19
18	7.04	2.20	1.69	10.93
19	7.02	2.43	1.79	11.24
20	6.88	2.54	1.88	11.30
21	7.24	2.69	1.97	11.90
22	7.24	2.78	2.01	12.03
23	7.05	2.84	2.07	11.96
24	6.83	2.91	2.12	11.86
25	6.90	3.03	2.19	12.12
26	6.98	3.11	2.27	12.36
27	7.05	3.18	2.35	12.58
28	7.05	3.29	2.43	12.77
29	7.07	3.39	2.52	12.98
30	7.28	3.43	2.62	13.33
36	7.22	3.64	2.71	13.57
43	7.38	4.06	2.85	14.29
53	7.47	4.24	2.91	14.62

evolved. Table II gives the total changes in weight for each day when weighings were taken; while Table III gives the increase in weight of oil, water and carbon dioxide evolved in terms of percentage of the oil. This table also gives the total oxygen absorbed, which is obtained by adding the carbon dioxide and water evolved to the increase in weight of the oil.

TABLE IV

DAILY CHANGES IN WEIGHT OF OIL AND WHITE LEAD

Day.	Increase in Weight of Flask, Grams.	Weight of H_2O Evolved in Grams.	Weight of CO_2 Evolved in Grams.	Total Oxygen Absorbed in Grams.
1	.0007	.0096	.0055	.0158
2	.0041	.0034	.0042	.0117
3	.0035	.0015	.0039	.0089
4	.0010*	.0027	.0036	.0053
5	.0093*	.0052	.0054	.0013
7	.0062	.0069	.0040	.0171
8	.0071	.0049	.0026	.0146
9	.0075	.0046	.0063	.0184
10	.0185	.0054	.0016	.0255
11	.0188	.0062	.0010	.0260
12	.0115	.0056	.0021	.0192
13	.0140	.0008	.0005	.0153
14	.0152	.0009	.0004	.0165
15	.0120	.0058	.0126	.0304
16	.0049	.0062	.0003	.0114
17	.0064	.0102	.0000	.0166
18	.0116	.0087	.0001*	.0202
19	.0057	.0121	.0028	.0206
21	.0104	.0125	.0023	.0252
22	.0125	.0071	.0010	.0204
23	.0138	.0074	.0011	.0223
24	.0189	.0085	.0034	.0308
25	.0241	.0052	.0014	.0307
26	.0299	.0055	.0017	.0371
27	.0416	.0061	.0021	.0498
28	.0570	.0069	.0025	.0664
29	.0275	.0135	.0070	.0480
30	.0281	.0079	.0057	.0417
31	.0186	.0037	.0030	.0253
32	.0115	.0040	.0031	.0186
33	.0061	.0085	.0036	.0182
35	.0062	.0105	.0079	.0246
36	.0071*	.0093	.0016	.0038

* Indicates decrease.

The experiment with the white lead was carried out in a manner similar to the experiment with the red lead, 5.0227 grams of oil, and 12.8639 grams of white lead being used. The experiment was run for 36 days. The darkening of the acid in the sulphuric acid tube occurred in the same manner and at about the same time. The results of this experiment are given in Tables IV, V, and VI. The results are plotted in the form of curves on Plates 1–6.

TABLE V

TOTAL GAIN IN WEIGHT EACH DAY FOR OIL AND WHITE LEAD

Day.	Total Gain in Weight of Flask Grams.	Total Gain Water in Grams.	Total Gain CO_2 in Grams.	Total Oxygen Absorbed in Grams.
1	.0007	.0096	.0055	.0158
2	.0048	.0130	.0097	.0275
3	.0083	.0145	.0136	.0364
4	.0073	.0172	.0172	.0417
5	.0020*	.0224	.0226	.0430
7	.0042	.0293	.0266	.0601
8	.0113	.0342	.0292	.0747
9	.0188	.0388	.0355	.0931
10	.0373	.0442	.0371	.1186
11	.0561	.0504	.0381	.1446
12	.0676	.0560	.0402	.1638
13	.0816	.0568	.0407	.1791
14	.0968	.0577	.0411	.1956
15	.1088	.0635	.0537	.2260
16	.1137	.0697	.0540	.2374
17	.1201	.0799	.0540	.2540
19	.1374	.1007	.0567	.2948
21	.1478	.1132	.0590	.3200
22	.1601	.1203	.0600	.3404
23	.1739	.1277	.0611	.3627
24	.1928	.1362	.0645	.3935
25	.2169	.1414	.0659	.4242
26	.2468	.1469	.0676	.4613
27	.2884	.1530	.0697	.5111
28	.3454	.1599	.0722	.5775
29	.3729	.1734	.0792	.6255
30	.4010	.1813	.0849	.6672
31	.4196	.1850	.0879	.6925
32	.4311	.1890	.0910	.7111
33	.4372	.1975	.0946	.7293
35	.4434	.2080	.1025	.7539
36	.4363	.2173	.1041	.7577

* Negative number.

The experiment on the drying of oil alone, which had been carried out last year, was repeated because the conditions were slightly changed especially with reference to the amount of air which was drawn through the apparatus. The results of this experiment are given in Tables VII, VIII, and IX. This experiment was not carried as far as it had been carried last year, and for this reason the total oxygen absorbed is not as great as was obtained last year.

TABLE VI

TOTAL GAINS EACH DAY BY PERCENTAGE, OIL AND WHITE LEAD

Day.	Increase in Weight of Oil Per cent.	Total Water Evolved in Per cent.	Total CO_2 Evolved in Per cent.	Total Oxygen Absorbed in Per cent.
1	.01	.19	.11	.31
2	.09	.26	.19	.54
3	.16	.29	.27	.72
4	.14	.34	.34	.82
5	.04	.45	.45	.86
6	.08	.58	.53	1.19
8	.23	.68	.58	1.49
9	.37	.77	.71	1.85
10	.75	.88	.74	2.37
11	1.12	1.00	.76	2.88
12	1.34	1.12	.80	3.26
13	1.62	1.13	.81	3.56
14	1.93	1.15	.82	3.90
15	2.17	1.27	1.07	4.51
16	2.27	1.39	1.08	4.74
17	2.39	1.59	1.08	5.06
18	2.61	1.77	1.08	5.46
19	2.77	2.00	1.13	5.90
21	2.94	2.26	1.18	6.38
22	3.19	2.39	1.20	6.78
23	3.43	2.54	1.22	7.19
24	3.82	2.72	1.29	7.83
25	4.32	2.82	1.32	8.46
26	4.92	2.92	1.35	9.19
27	5.75	3.04	1.39	10.18
28	6.88	3.19	1.44	11.51
29	7.43	3.44	1.58	12.45
30	7.98	3.62	1.70	13.30
31	8.35	3.69	1.76	13.80
32	8.58	3.78	1.82	14.18
33	8.72	3.94	1.89	14.55
35	8.82	4.14	2.05	15.01
36	8.71	4.33	2.08	15.12

These results have been plotted in the form of curves, the increase in weight of the paint alone being shown on Plate 1. This plate shows the very rapid absorption of oxygen by the oil when mixed with red lead as compared with white lead paint and oil alone. Plate 2 gives the water evolved and shows that more water is evolved from the oil alone than from oil with red lead, and that the oil and red lead give off water more rapidly than oil and white lead. The evolution of water, however, should be considered in connection with the absorption of oxygen in order to learn what effect the pigment has upon this phenomena. As the oil dries so much more rapidly with red lead than with white lead or when no pigment is present, a larger evolution of water is to be anticipated.

On Plate 3 the relative amount of carbon dioxide given off is shown. The red lead paint gives off carbon dioxide more rapidly than the white lead paint or oil alone. The total oxygen absorbed

TABLE VII

DAILY CHANGES IN WEIGHT OF OIL ALONE

Day.	Increase in Weight of Flask. Grams.	Weight of H_2O Evolved in Grams.	Weight of CO_2 Evolved in Grams.	Total Oxygen Absorbed in Grams.
1	.0049*	.0150	.0043	.0144
2	.0057	.0083	.0008	.0148
3	.0031*	.0097	.0046	.0112
4	.0086	.0098	.0028	.0212
6	.0048	.0124	.0017	.0189
7	.0081	.0085	.0014	.0180
8	.0053	.0084	.0038	.0175
9	.0002	.0095	.0038	.0135
10	.0023	.0138	.0087	.0248
11	.0064	.0169	.0031	.0264
13	.0112	.0160	.0005	.0277
14	.0021	.0064	.0027	.0112
15	.0003	.0066	.0028	.0097
16	.0018	.0064	.0030	.0112
17	.0070	.0062	.0024	.0156
18	.0084	.0061	.0024	.0169
20	.0219	.0081	.0029	.0329
30	.2460	.0389	.0120	.2969
34	.2370	.0626	.0124	.3120

* Indicates decrease.

Edward Barrow.

is shown on Plate 4. This shows in a very striking manner the rapid drying effect of the red lead on the oil, and the very slight effect of white lead.

Plate 5 gives the ratio of the amount of water evolved to the oxygen absorbed. It will be noticed from this plate that for a given amount of oxygen absorbed, the oil alone gives the maximum evolution of water. White lead paint gives a much smaller quantity and the red lead paint very much less. It will be noticed that the rate of evolution of water increases in the case of the red lead and decreases in the case of the white lead, so that ultimately the two curves cross, showing finally the amount of water evolved from the two paints to be identical.

This investigation was undertaken with the expectation that a marked difference might be shown with reference to the amount of water evolved with different pigments, and that a reason might

TABLE VIII

TOTAL GAIN IN WEIGHT EACH DAY, OIL ALONE

Day.	Total Gain in Weight of Flask in Grams.	Total Gain of Water in Grams.	Total Gain of CO_2 in Grams.	Total Oxygen Absorbed in Grams.
1	.0049*	.0150	.0043	.0144
2	.0008	.0233	.0051	.0292
3	.0023*	.0330	.0097	.0404
4	.0063	.0428	.0125	.0616
5	....	....	....	....
6	.0111	.0552	.0142	.0805
7	.0192	.0637	.0156	.0985
8	.0245	.0721	.0194	.1160
9	.0247	.0816	.0232	.1295
10	.0270	.0954	.0319	.1543
11	.0334	.1123	.0350	.1807
13	.0446	.1283	.0355	.2084
14	.0467	.1347	.0382	.2196
15	.0470	.1413	.0410	.2293
16	.0488	.1477	.0440	.2405
17	.0558	.1539	.0464	.2561
18	.0642	.1600	.0488	.2730
20	.0861	.1681	.0517	.3059
30	.3321	.2070	.0637	.6028
34	.5691	.2696	.0761	.9148

* Indicates negative quantity.

be found for the very marked protective action against corrosion shown by red lead paint over white lead and other paints. The amount of water given off during the drying of linseed oil must have a very marked influence toward the rusting of iron and steel. If a pigment, such as red lead, during the drying evolves a smaller amount of water, it is reasonable to expect that less rusting would be noticed and that it would be a better protective paint for iron and steel.

Carbon dioxide is also known to be an active corroding agent, especially in the presence of moisture. As shown by Plate 6, the amount of carbon dioxide given off during the early stages of the drying of red lead is very much less than that given off by a white lead paint, but curiously enough, the white lead paint gives off more carbon dioxide than pure linseed oil.

This taken in connection with the smaller amount of water given off by the red lead film may very readily be supposed to account for the protective action of the red lead paint. It seems

TABLE IX

TOTAL GAINS EACH DAY BY PERCENTAGE, OIL ALONE

Day.	Increase in Weight of Oil Per cent.	Total Water Evolved in Per cent.	Total CO_2 Evolved in Per cent.	Total Oxygen Absorbed in Per cent.
1	.09*	.29	.08	.28
2	.02	.45	.09	.56
3	.04*	.64	.19	.79
4	.12	.83	.24	1.19
6	.22	1.08	.28	1.58
7	.37	1.24	.30	1.91
8	.48	1.41	.38	2.27
9	.48	1.59	.45	2.52
10	.53	1.86	.62	3.01
11	.65	2.19	.68	3.52
13	.87	2.54	.69	4.10
14	.91	2.67	.74	4.32
15	.92	2.80	.80	4.52
16	.95	2.93	.86	4.74
18	1.25	3.18	.95	5.38
20	1.68	3.33	1.01	6.02
30	6.46	4.04	1.25	11.75
34	11.10	5.26	1.49	17.85

* Indicates negative per cent.

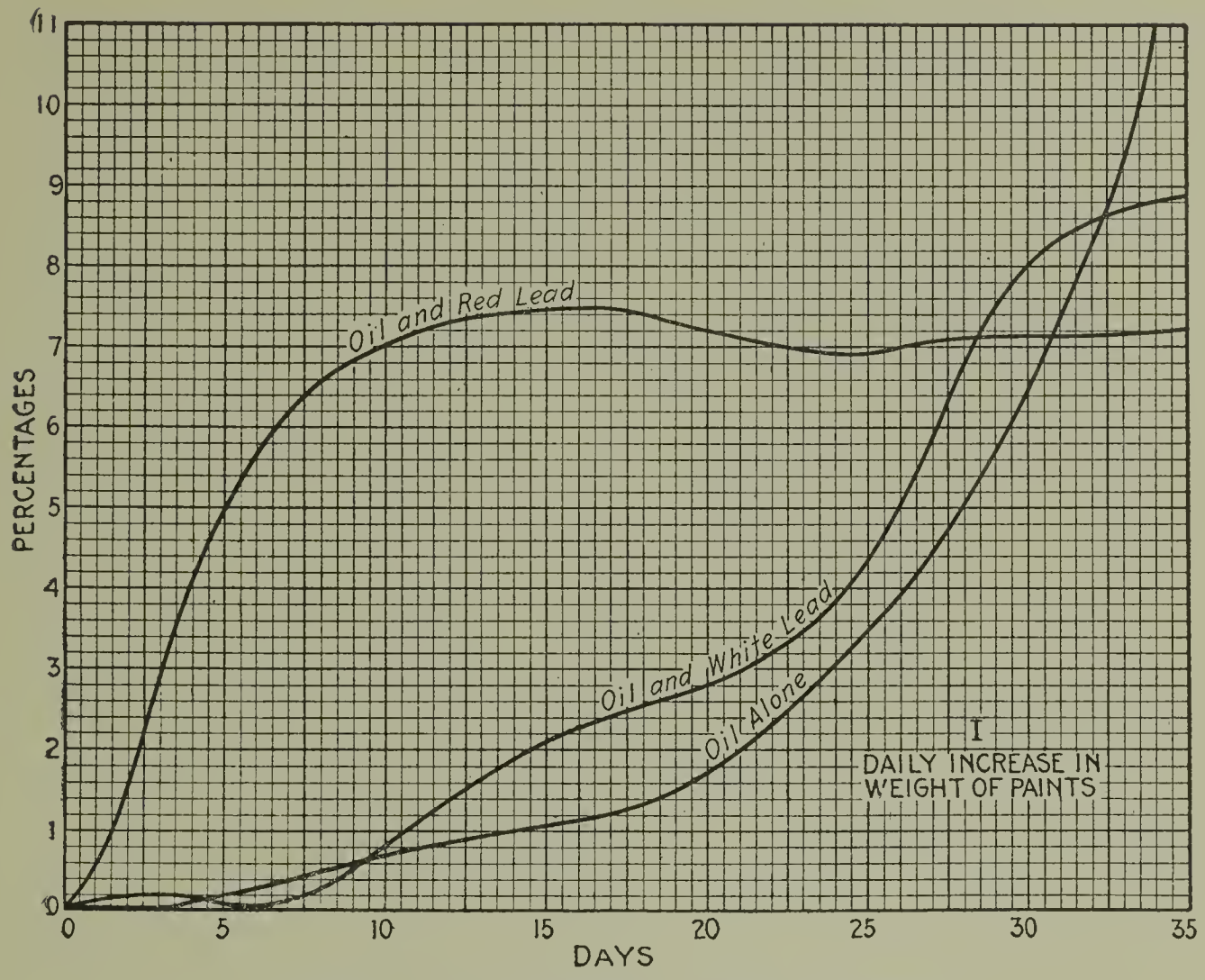

PLATE I.—Daily increase in weight of paints.

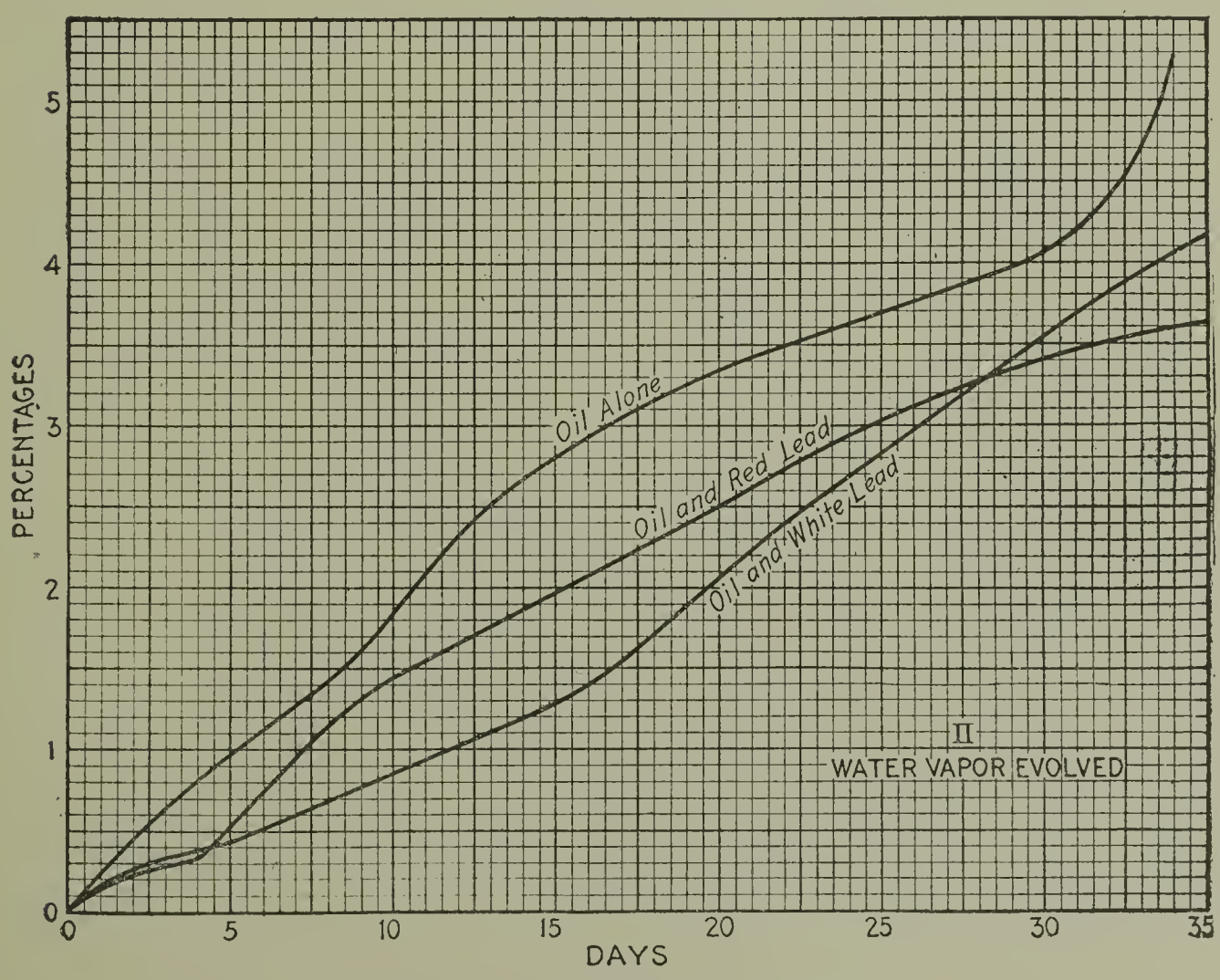

PLATE II.—Water vapor evolved.

to be true that ultimately the *same amount* of carbon dioxide and water is given off by both red lead and white lead paint, but it

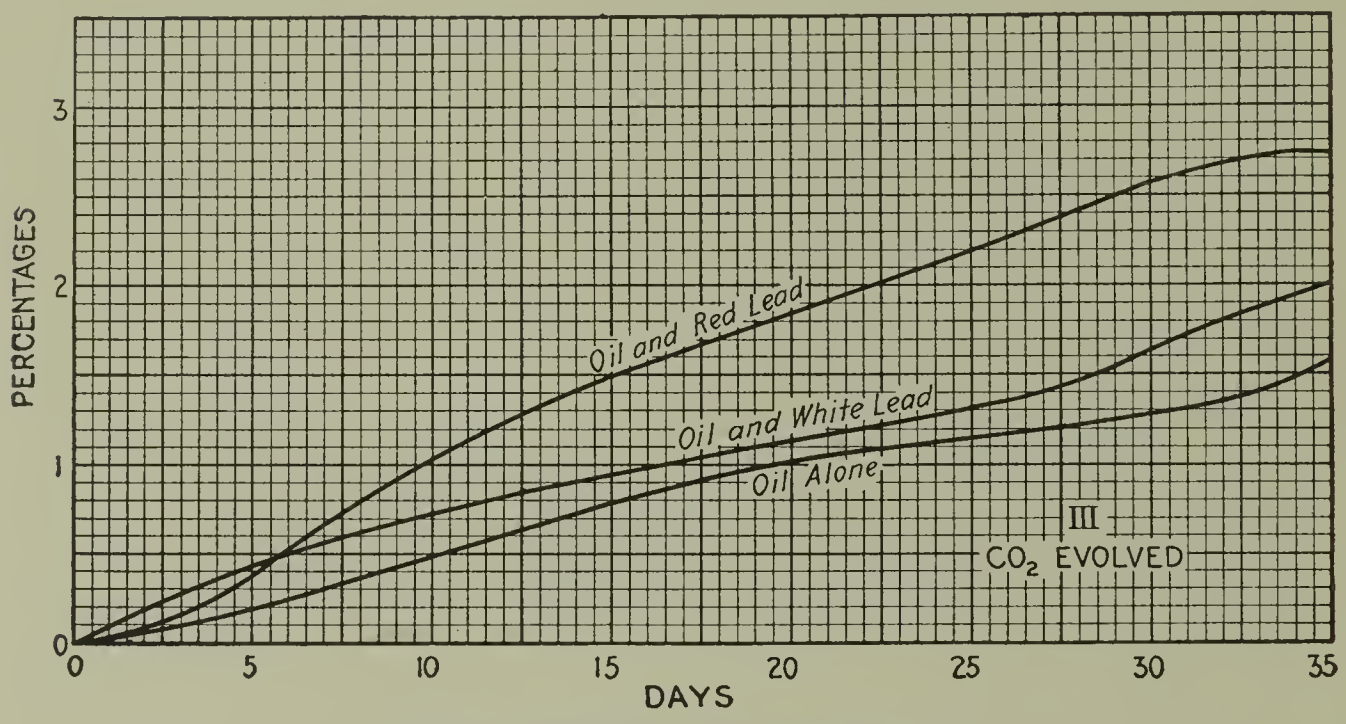

PLATE III.—Carbon dioxide evolved.

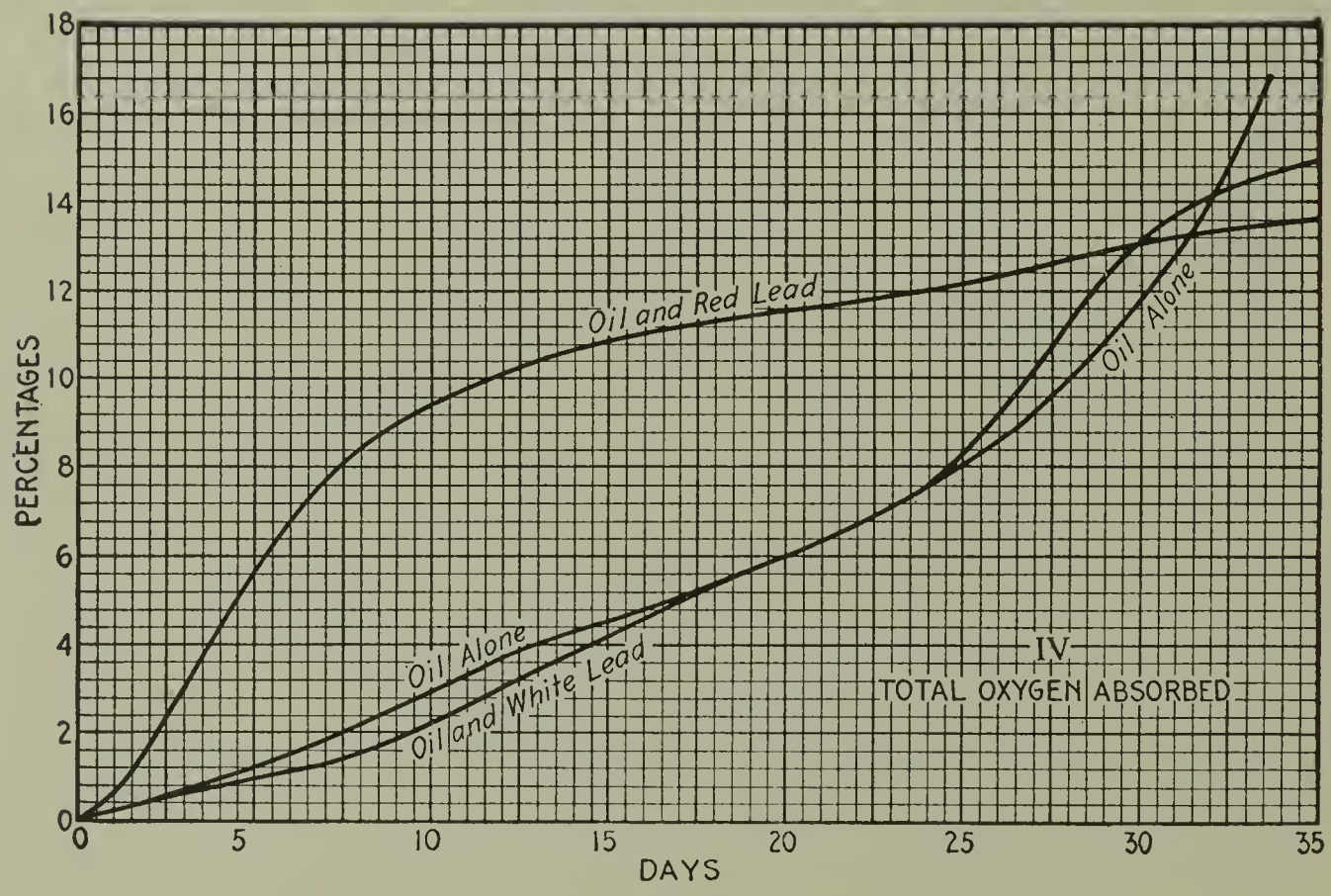

PLATE IV.—Total oxygen absorbed.

may be supposed that by the time the red lead paint is giving off the water and CO_2 the hardened paint film has prevented the action of the moisture and carbon dioxide on the iron or steel.

It is of interest to inquire as to why the water and carbon dioxide are apparently held back by the red lead. It does not seem reasonable to suppose that the character of the oxidizing

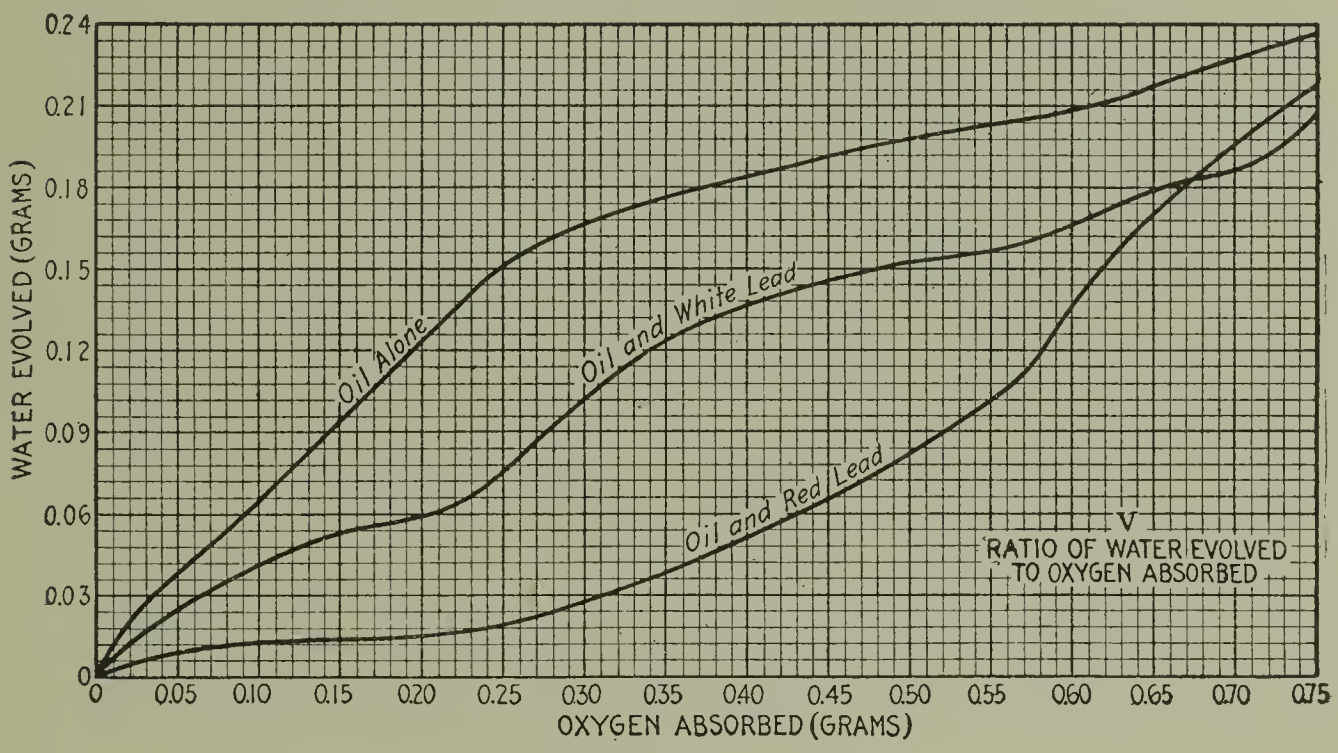

PLATE V.—Ratio of water evolved to oxygen absorbed.

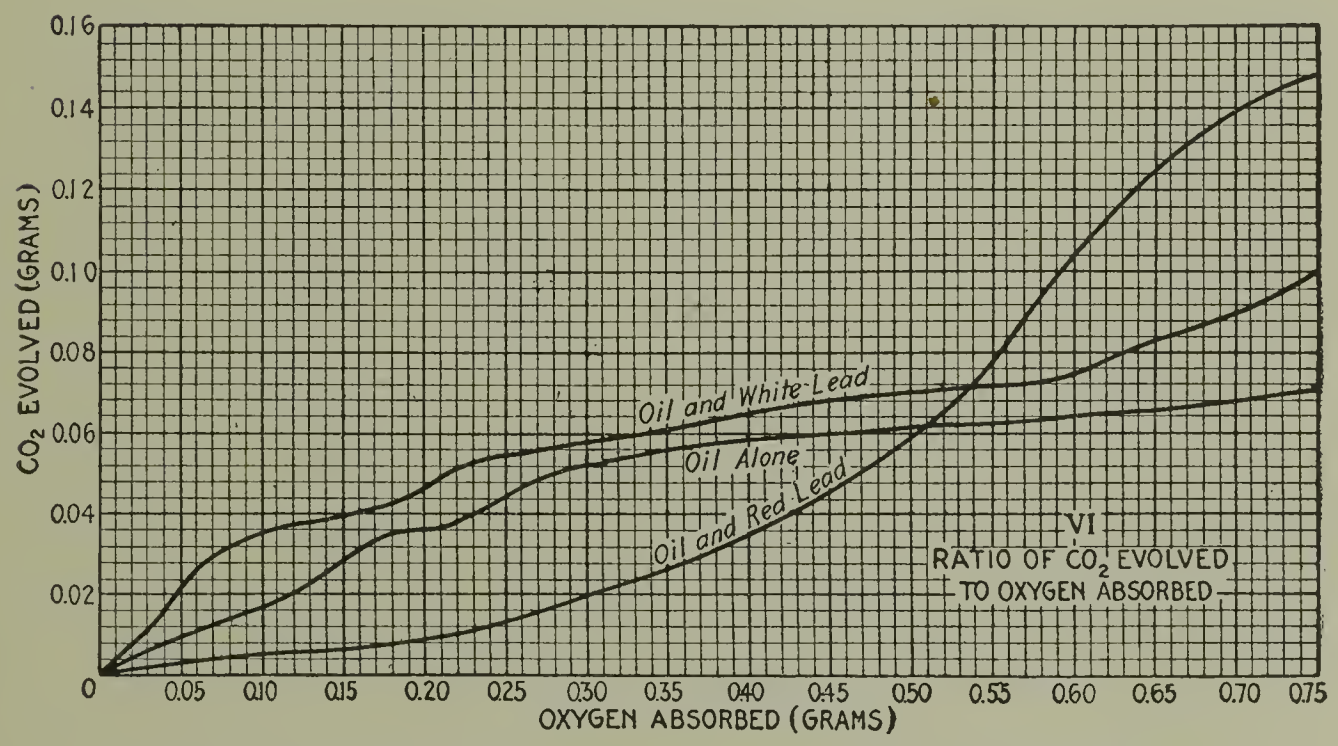

PLATE VI.—Ratio of carbon dioxide evolved to oxygen absorbed.

action on the linseed oil should be fundamentally changed on account of the pigment. It seems more reasonable to suppose that the red lead is capable of combining with moisture and car-

bon dioxide. This would be especially probable if some of the available oxygen of the red lead was taken up by the oil in the process of drying, leaving litharge, which could readily combine with water and carbon dioxide, producing white lead. The fading of the color of the red lead paint would indicate a change of this character. It may also be possible to dissolve the oxidized oil and analyze the pigment for available oxygen, carbon dioxide and water. This experiment will be carried out in the future for the purpose of ascertaining if the carbon dioxide and water, which is not evolved, has been held back by the pigment. It will also be possible to test this theory by using red lead containing litharge.

DISCUSSION.

Dr. WAGNER: "Any of the members wish to ask any questions?"

Dr. ITTNER: "These curves would lead me to believe that the practice of covering the red lead coating, where it is used as a protection to iron, by applying over it an outer coating would seem to be a good one. The action of the oxygen of the air in decomposing the oil with the formation of water and carbon dioxide is in all probability brought about catalytically and an outer coating of some inert material might therefore retard or prevent this. In a recent paper read by Dr. Walker in New York, he said the best practice in protecting iron and steel with red lead was to use an outer paint, something on the order of graphite paint. Such a paint probably protects the red lead coating from the injurious action of too much oxidation.

Sec. OLSEN: "It seems to me that if you paint the surface with red lead and then afterward coat it with another paint pigment, that it would, according to these curves, make a better protective coating. For instance, Plate V shows the water evolved from oil and red lead. During the first week to ten days the evolution of water from the red lead would be comparatively slight, but as the observation continues, the water would be evolved at a very rapid rate. Dr. Walker's suggestion is that if you coat red pigment after reaching this stage of oxidation, you can prevent the remainder of the oxidation and therefore it would be better protective coating."

Mr. MASON: "What was the purpose of this experiment?"

Sec. OLSEN: "They were carried on in a glass flask to get increase of weight, and CO_2 evolved, and water evolved in the same experiment. It was therefore carried on in a glass flask.

"If steel or any other surface were used it might be different, but if you can coat glass with a pigment or paint you can coat any kind of a surface. It is perfectly feasible as an experiment."

A PECULIAR FORM OF LAKE POLLUTION

By WM. P. MASON

Read at the Boston Meeting, June 27, 1913.

The Lake to which attention is asked in this instance is one of the so-called "finger lakes" of western New York. Its length is about ten miles, breadth one mile, and its water-shed about 190 square miles; its depth is about 175 feet. A small stream enters its head, and a city of some 30,000 inhabitants has its intake located at the north end or foot of the lake, at a depth of about 40 feet. The temperature of the water at that point in May, 1913, I found to be 42 degrees F.

The peculiar feature of the case which has especial interest to us is the possibility of polluting material of fecal character being transported from a village near the head of the lake down the inlet stream and then northward, for the entire ten miles of the lake's length to the city intake situated at the lake outlet.

We have all faithfully held to the dictum that "sedimentation and time" are the great purifying agencies upon which to rely for the natural improvement of a once polluted water; and it takes a good deal of evidence to persuade us that the sewage of a small village could make the trip down such a lake in a length of time and in such a manner as to affect dangerously the water of the lower end. Experimental data, however, have been secured showing that such a result actually takes place. Investigation showed the following facts: The village sewage was, of course, small in volume, but during the winter months it was deposited at several points upon the banks of the inlet stream and there accumulated in a more or less frozen condition until the occurrence of the spring thaw, at which time there was opportunity for such accumulated material to be washed into the lake in state of suspension, and there was also a chance of its being actually ferried upon cakes of ice, because of the existence of privies located upon bridges,

whence fecal matter was dropped upon the very center of the ice covered stream.

Note has been made that the shape of the lake is long and narrow, and that it lies north and south. It must be further noted that the prevailing wind is from the south, with a tendency to blow the surface water directly toward the city intake at the north end.

By means of triangulation and the use of floats constructed so as to be moved by water currents existing at the different levels of from five to twenty feet, it was ascertained that the upper strata of water actually moved northward with the wind as would have been expected. The rate of this movement being ascertained, it was found that with relatively light winds the movement of the water down to a depth of five feet amounted to about three per cent. of the wind movement, while at lower depths this water movement diminished to as low as three-quarters of one per cent. of the wind movement. Thus, to quote from the figures of Mr. Ackerman, who made these tests, with a wind movement of six miles per hour the per cent. which the water movement was of the wind movement was as follows:

At 5 feet depth	3.2 per cent.
At 10 feet depth	1.74 per cent.
At 15 feet depth	0.87 per cent.
At 20 feet depth	0.75 per cent.

With a higher wind velocity the water also traveled with greater velocity, but its movement was not so large a percentage of the wind movement. Thus with a wind blowing 17 miles an hour the water movement amounted to but one-and-a-quarter per cent. of that of the wind as estimated at the five foot depth. From these data it was easy to calculate that pollution entering the head of the lake could make the trip to the foot of the lake in about three days.

Knowing as we do, from Houston's experiments, that cold water below 50 degrees F. will favor the longevity of the typhoid fever bacillus, it is easy to see how entirely possible it would be for living germs to reach the intake in dangerous condition.

It will be noted the striking resemblance which some features of this case bear to the classic instance of the outbreak of typhoid fever at Plymouth, Pennsylvania, where the whole trouble came

from the dejecta of a single individual being thrown out upon a hillside, where it froze and accumulated for weeks and finally, upon the coming of the thaw of spring, was washed into a stream tributary to the city reservoir. This sudden washing of accumulated fecal material furnished in both of these instances a volume of pollution out of all proportion to the amount which would be daily derived from the contributing population during ordinary times of fair weather, with the result that it overtaxed and broke down Nature's ordinary means of purification and protection.

There is no question but that this particular case, showing as it does the dangers that may arise from such winter accumulation, and showing further the possibility of transportation of such material over large distances in a lake, provided conditions are suitable, will cause many of us to amend materially our notions about lake and reservoir storage. I would not wish for a moment to underestimate the great advantage of such storage, for the reason that I firmly believe that it furnishes our main safeguard in preventing disease arising from the use of polluted waters which have not been subjected to artificial improvement; but I cannot help but feel that we should not trust to simple storage without a thorough knowledge of just how such storage is being accomplished. I have in mind at the present moment the case of a large lake some five miles in length, which has a stream entering within one mile of a city intake, and I have observed that there is a possibility of such stream, because of its water having a low specific gravity, flowing over the surface of that lake toward the intake. The great length of the lake would, under such circumstances, be of small value for purification purposes.

All of this certainly goes to show that we should be cautious about banking too strongly upon the efficiency of lake purification under all circumstances, and it demonstrates the necessity of our being well acquainted with the conditions surrounding each individual case before venturing an opinion on the matter.

THE RELATION OF THE MANUFACTURER TO OUR PATENT SYSTEM

By W. M. GROSVENOR.

Read at the Boston Meeting, June 25, 1913.

About a year ago a statistical paper[1] was read before a joint meeting of chemical societies on "Patents and the Chemical Industry in the United States." At the time this was not seriously discussed or commented upon by your Patent Committee because the paper represented so much work that it seemed a pity to sharply criticize conclusions modestly offered. But the paper seems to have been read by many people lacking in practical comparative and critical faculties, and the astonishing conclusions it offers appear to have been swallowed whole by so many unthinking readers that a careful criticism of the paper is demanded.

The statistics were prefaced with the statement that "*The close interrelation between patents and the development of modern industry is a subject receiving sufficient consideration on the part of economists.*" This is unfortunately not true in the United States. In Germany the Government is revising the Patent Laws, making them in most respects more like our own. In this work the suggestion and the coöperation of manufacturers, engineers, agents, corporation lawyers and patent attorneys is sought. Such a method is far more promising of practical benefit than the "consideration" of our "economists," some of whom would hardly know a patent if they saw one, and a majority of whom apparently regard public hearings as mere formalities to be ignored in actual procedure. In this country we haven't even the sufficient attention of the "economists" unless the patent commissioner and the politician who get together for mutual benefit at the expense of the Patent System can be called in certain senses economists. They may be entirely sincere in their motives but the "reforms" they have advocated are so plainly in the interest of the "Trusts" that we must either believe them influenced or question their intelligence.

The author of that paper recognized the strong tendency on

[1] Herstein, *The Jour. of Indus. and Eng. Chem.*, 4, 328.

the part of inventors to distrust the protection of patents and stated that already inventors prefer to keep improvements secret rather than patent them. He admitted that even with the right of patenting the product (if new) his secrecy is "only partially overcome," but he does not frankly state the actual reason. He either does not know, or else ignores it entirely because it would disagree with the trend of his comments and conclusions. Those who have to recommend or decide what shall be done in these cases realize that it is because the right in intellectual property is too insecurely granted by the U. S. patent; because the grant is only a contingent liability, a right to sue; because our "priority of conception" doctrine with its interference proceedings, helps to make the title to any invention problematical even after a patent grant; because searches, often slovenly, are made through a woefully incomplete and partly unclassified record of the prior art, in part at least by underpaid assistants waiting to pass their law exams. and find another job; because the absence of public opposition or expert advice from practical men makes those searches academic; and because by every technical complication from the drawing of our claims as permutations of hair splitting, through the multiplicity of appeals to our court practice as it has been (rules of procedure) and to some extent still is (9 circuits with untrained judges and contradictory decisions), the great advantage is given at every step to mere money power. If real estate titles were subject to all these risks, liabilities and uncertainties, who would care to buy a home? Why should brain property be thus jeopardized!

So when he were informed that "*as a whole the progress of industrial chemistry in recent years is* RECORDED *in patent literature*" it is because the paper was written by a statistician not himself a practical, technical chemist. It would be surprising if true. Actually progress is barely indicated, as incompletely as the law permits, only for those things that can't be kept secret and only after it becomes necessary to issue the application in order to defend as best we may rights that are being overrun.

Let us proceed to the statistics appended—a magnificent piece of statistical work—which it is stated "*should not by any means be regarded as including those patents relating to chemical industry which are classified under other divisions or sub-divisions*" in other words, many of the most important truly chemical patents, separately classified because most important.

It was then pointed out as an awful condition of things that the number of chemical patents issued to German citizens (1754) is greater than that issued to U. S. citizens (1552), that German parentage claims 701 to our 19 of the patents for carbon dyes, 79 to our 31 on dyeing processes and 450 to our 130 on carbon compounds. If these figures really tell the story of chemical industry as the paper endeavored to show, how terrible the tale would appear to be. But the practical man is apt to ask, "Well, what do you mean? What is it all worth?"

In the first place we note from the figures themselves that 1754 patents were issued to Germans for *all chemical inventions* and 1246 (or 70 per cent) for *these three groups* (carbon dyes, carbon compounds and bleaching and dyeing). Do *these three little groups* constitute, as would thus appear, over 70 per cent of all chemical industry? We seem to see a light.

In the next place, the grand total value of carbon dyes imported to the U. S. last year approximated $9,000,000, and the total of all products of this class $81,000,000. New York eats $25,000,000 worth of eggs. Is it possible that 81 million is 70 per cent of all the products of what we call "chemical industries?" The whole carbon dye business is about the size of our little aluminum business started at Niagara Falls under an American patent. Also the total $81,000,000 is about the same as the value of sulfite and caustic pulp made last year, another American invention. We even made ourselves in the U. S., $16,000,000 worth of drugs and extracts, not counting patent medicines. In the 1900 census, over 200 millions worth of chemical products are recorded as such, not including the separately classified industries. Furthermore, simple division shows *each* of these terrible German patents to represent a total gross business in the U. S. of about $70,000 a year. Let us compare this with some American inventions. Last year we made about 90 millions of wood pulp and we vulcanized about 93 million dollars' worth of rubber, made 10 millions of aluminum above indicated, 6 millions photographic materials, 3 millions of pyroxyline plastics, 6 million dollars' worth of oxide matches, 3 million dollars' worth of calcium carbide, and nobody knows just how much nickel steel, with carborundum, alundum, Acheson graphite, bakelite, etc., climbing up to join the procession. Instances of real chemical products in quantities many times $10,000 a year, made under patents of U. S. inventors, could be multiplied almost indefinitely.

Let us even take the statistician's standard for measuring progress as indicated by number of patents. Look at the relative progress of the U. S. and Germany in other lines (some more important than dyes) that this table (admittedly limited) covers. We find alkalies and chlorine 70 to 4, bleaching and disinfecting 20 to 12, chlorates 7 to 1, dyes and pigments 19 to 0, carbides 58 to 3, tanning 5 to 0, bleaching 30 to 17, dyes (not carbon) 16 to 10, mercerizing 29 to 10, mordants 21 to 13, mineral acids 116 to 62, fire extinguishing compounds 5 to 4, *catalytic bodies 5 to 10*, metalloids 55 to 14, packing chemicals 10 to 2, apparatus 40 to 10, salines 146 to 98, *ammonia 6 to 27*, soda and potash 24 to 9, nitro compounds 97 to 28, extracts 44 to 18, *internal remedies 23 to 52*, tropical remedies 45 to 20, insecticides 69 to 6, disinfectants 240 to 19, pyroxalines 20 to 10, *viscose and cellulose 17 to 28*, plastics 12 to 0, glue 12 to 8. In each of the 9 divisions of coating compositions we exceed totalling 80 to 20, as also in ammonia, water, and wood distillation total 35 to 7. There are not many italicized branches in which Germany seems to take more patents. And consider the relative commercial importance of alkalies and chlorine 15 million, carbides 4, mineral acids 20, tanning 204, bleaching 3, salines 10, soda and potash 18, nitro compounds 16, internal remedies 23, pyroxyline plastics 3, or glue 6, along with fertilizers 50, copper smelting 165, lead smelting 175, glucose 21, paints 50, soap and candles 53 and sugar 250 million, as compared with coal tar dyes 9 or the whole 81 million about which so much noise is made.

And yet what awful "conclusions" this little bunch of German dyes produced in the paper and what horrible things we are advised to do to our patent system and chemical industries producing over 1000 million a year because 80 millions worth of German chemicals are imported or rather because 1151 patents are granted to Germans. Suppose I say that they paid our Patent Office $26,775 and paid our attorneys about $115,000 and therefore urge the importance of retaining the present law as it is. This would be about as sane as for any one to call "dyes" and "carbon compounds" the chemical industry and seek on account of these relatively unimportant groups to perform criminal malpractice on our whole patent system. Why that paper would have us abolish the "product patent" and introduce compulsory working for a matter of about 80 million dollars worth of imported products a year!

Statistics are, as we have seen, valuable and instructive, but the conclusions drawn and recommendations made in this paper are outrageous, contradictory of the common sense interpretation of the very figures on which they are supposed to be based and flatly contradicted by more complete facts in the specific case. For instance, "*In the United States the progress of chemical industry must be traced not by the broadening of domestic production but in imports only.*" It seems incredible that with any study of the field a writer should have made this statement. Let us have a few real industrial statistics. [In the selection of the statistics of industries, I wish to thank Mr. O. C. Hagemann for generous assistance.]

The latest census figures show the value of all products of the United States chemical industries to have risen from $757,127,000 in 1900 to $1,479,000,000 in 1910; doubled in ten years.

IMPORTED COAL TAR CHEMICALS AND OTHER SUBSTANCES. (*a*)

		Year ending June 30, 1912.	
Include	Acid, carbolic	$ 521,457	
	Alizarine	1,386,529	
	Aniline oils	175,120	
	Aniline salts	386,656	
	Other coal tar chemicals	10,755,160	
			$13,224,922
		Year ending June 30, 1912	
	Forward		$13,224,922
Exclude	Balsams	$ 138,000	
	Barks, beans, etc.	2,391,606	
	Ergot	187,000	
	Flowers and leaves	704,547	
	Gums	10,480,396	
	Jalap	27,607	
	Nutgalls	329,457	
	Opium	2,020,026	
	Potash muriate	7,235,728	
	Roots	1,688,865	
	Saffron	90,202	
	Soda nitrate (Chili)	15,427,904	
	Tonka beans	201,131	
	Vanilla beans	2,025,153	
	Wax, vegetable	1,080,198	$44,027,820
			$57,252,742
Total chemicals, drugs, dyes—imported in 1911–12			90,878,000
Deduction as above			44,027,820
Remnant			46,850,180

(*a*) Some of these should be excluded from the imports when comparing United States productions with imports of chemical manufactures.

Included are lubricating oils, baking powder, blacking, blues, printing ink, candles, pharmaceutical preparations, tanning and dyeing extracts, paints, colors, artificial manures, glues, fats and oils, inks, pigments, perfumes, refined mineral oils, soap, starch, turpentine, resins, varnishes, products of destructive distillation and chemicals in the narrower sense.

The production of these chemicals in the narrow sense has grown from $62,637,000 in 1900 to $117,689,000 in 1910, an increase of $55,052,000 or 88 per cent.

The imports of "chemicals" amounted to $37,559,000 in 1900 and $63,388,000 in 1910, an increase of $25,829,000, or 69 per cent.

If from the imports of all "chemicals," drugs and dyes, $90,878,000 we should strike out Chile saltpeter, German crude potash salts and natural raw materials like leaves, bark, etc., =$44,027,000, the chemical, dye and drug imports that we might manufacture remain a modest total of $46,850,000.

This remnant amounts to not more than 40 per cent of our present home produce of strictly chemical preparations and less than 4 per cent of products of our really chemical industries.

In examining detailed items we find:

RAPID PROGRESS IN MANUFACTURING AND THE MORE STATIONARY CONDITION AND DECLINE OF IMPORTS, IN THOUSANDS OF DOLLARS

	Production.			Imports.			
	1900	1905	1910	1900	1905	1910	1910 Imp. Prod. Per Cent.
Acetic acid	396	538	1136	18.00	16.00	82.00	7.2
Alum and alum cake	..	..	2580	19.00	23.00	31.00	12.0
Boracic acid	198	527	296	17.00	23.00	13.00	4.4
Borax	502	2123	1767	2.00	13.00	1.00	0.1
Chlorates	..	..	940	195.00	146.00	266.00	28.3
Chloride of lime (bleach)	..	..	1507	1461.00	776.00	750.00	49.7
Chloroform	58	166	473	0.3	0.29	1.4	0.3
Citric acid	..	599	777	14.0	0.72	9.0	1.1
Epsom salts	46	146	358	2.0	31.0	27.0	7.5
Glycerine	2013	5348	11728	21.2900	2050.00	3674.00	31.3
Phosphoric acid	..	68	506	21.00	26.00	47.00	9.4
Potassium cyanide	591	496	1478	444.00	260.00	328.00	22.2
Prussiate yellow	994	683	464	224.00	103.00	229.00	49.5
Soda ash	4768	8202	10362	665.00	167.00	55.00	0.6
Sodium bicarbonate	1325	1136	1515	4.00	6.00	4.00	0.3
Soda caustic	2918	2924	5216	158.00	35.00	33.00	0.6
Sodium phosphate	105	244	500	43.00	1.00	1.00	0.2
Sulphuric ether	130	335	199	0.03	0.16	0.07	0.1
Zinc salts	..	..	1478	37.00	31.00	36.00	24.4

To which may be added a list showing our development in some cases not directly comparable with imports because the latter are not separately listed:

Production.	Values in $1000.		
	1900	1905	1910
Acetone	178	161	703
Alkaloids	1743	2926	3188
Ammonia sulphate	331	681	3227
Anhydrous ammonia	448	1173	2503
Anhydrous carbonic acid	696	1344	2318
Bleaching materials aside from hypochlorites	492	778	1635
Calcium carbide	680	....	2984
Fine chemicals, aside from alkaloids, salts, of gold, silver, and platinum, chloroform, ether, acetone	1426	4249	5200
First distillation products from coal tar	800	341	2462
Hydrofluoric acid	35	251	215
Mixed acids	1111	....	1860
Muriatic acid	1020	....	1171
Nitric acid	1455	....	1357
Plastic masses	2099	4756	7180
Sulphuric acid	7679	....	10084
Tin salts	470	905	1195

In view of the facts, any statement that growth is shown by imports only would be humorous were it not that many are deceived.

The author of that paper offers ". . . *to point out anew those characteristics of our patent legislation which, in their bearing on chemical industry at least, are calculated to retard rather than to promote the development of manufactures in the United States.*" We have seen how retarded is chemical industry broadly. If in some small section (as carbon compounds or dyes) we find the contrary, it must be charged to neglect by our manufacturers or their false economy of chemical research, or some other cause peculiar to that specific line, not to patent laws, or the tariff that equally affect lines in which we have seen such phenomenal growth of production.

"*Chemical manufactures are but a small, even if a very important, part of our industrial structure.*" The last general census showed about 13 thousand million total manufactures of which 1400 million (11 per cent) were chemical and allied industries, and the strictly chemical classification exceeded 117 million. So we are forced to conclude that dyes and carbon compounds are all the

author considers as chemical manufactures, or that he has some special interest to serve in ignoring "the other ninety and nine."

"*Expressed in number of patents taken out, the figures quoted before show that scarcely more than one per cent of patents issued cover invention properly (arbitrarily?) called chemical.*" How PROPERLY and how ARBITRARILY we have seen.

"*No one at all acquainted with the subject will deny, and a study of the foreign trade statistics will immediately show, that the building up of chemical industry in this country has been extremely onesided.* I have a remote bowing acquaintance with the subject and emphatically deny the statement. Furthermore, trade statistics do not show it, as you have seen, unless mere number of paper patents are "trade statistics." In fact, it is denied in the next sentence though the author didn't know it. He says: "*The manufacture of heavy chemicals on the one hand is in most respects on an equality with the best anywhere and the same is true of staple, organic and medicinal chemicals.*" Any one of these three is comparable with the organic dyes' 9 million and he ignores wood distillation products 4 million, pyroxylin and similar plastics 7, glycerin 12, our own dyestuffs and extracts 15, electrochemicals 18, turpentine and rosin 25, explosives 40, glucose and starch 48, fertilizers 104, soap 111, paints and varnishes 124, cottonseed oil and cake 147, gas and by-products 167, petroleum products 237 and refining of metals over 300 million, and numerous other branches of industry which are strictly chemical in character, though specially classified just because of great importance. Most of them are far more important than carbon dyes or drugs. The per capita development of the U. S. in any of these branches is by no means backward. Unless one judges by mere number of paper patents it is hard to see how even the complete and absolute absence of two items like carbon dyes and compounds (81 million dollars) could make us "extremely one sided" with 1400 million dollars of chemical products.

When it comes to reasons for this supposed one-sidedness, we find, "*And this is not for want of raw materials or other primary elements essential for the existence of such manufactures, but more so because both tariff and patent legislation have created a situation forcing enterprise in one direction and preventing it becoming engaged in the other.*" I wonder what this means. We have the same patent and the same tariff for dyes and fine chem-

icals as for hundreds of other products that aren't "backward." It is impossible to regard those laws as the sole or even the chief cause of the backwardness. Perhaps the figures themselves offer a true and ample reason in the mere number of patents that has caused so much worry. A business that requires 300 patents and the unlimited research they imply when the gross business involved in each one promises to be only $70,000 a year, does not appeal to the U. S. manufacturer. It breaks the Yankee heart of the average American manufacturer to spend money on research, but he will get over that some day. At present some very large corporations have the breadth of view to see the advantages, but the ordinary company frequently fails in the first attempts and in consequence generally becomes discouraged. The puttering detail of such a business is apt to be scorned by large American companies. Admitting the aggregate value and the profit, still they simply do not care to go into it. Besides, our workmen are ill adapted to small manufactures of fine chemicals. The few firms that are doing such work in the U. S. rely chiefly on foreign labor, particularly German, Hungarian and Polish, and these men, in spite of every effort on the employer's part to preserve their native conditions, rapidly change their habits and method of work. Versicherungs Gesellschaften und Turn Verein, 10 o'clock Frühstück, beer throughout the plant, etc., fail to preserve the faithfulness to detail, simplicity of life and economy of expenditure that prevail in the Vaterland and that are necessary to make such puttery work profitable. Thus we see that the number of patents instead of showing the importance of the industry is only one of the evidences of the fussy character that unfits it for our special industrial conditions—the fussy character and not the maligned patent system making us backward in this little field. As a matter of fact I am reliably informed that many of these German specialties are made with little or no profit even in Germany.

In its effort to hold the patent system responsible, the statistical paper contains a most remarkable implication: *"Unlike the heavy chemical industry, the manufacturer of fine chemicals derives its profitableness exclusively from patents."* We are thus tempted to forget or ignore that, in the sulphuric acid industry, patents cover all practical mechanical furnaces, the three really efficient dust collectors, the four most modern types of chambers, three of the four systems of concentration, and all available contact systems;

that in nitric acid the Uebel, Valentiner, Guttmann, and Jahn systems and all efficient direct synthetic methods are patented; that in muriatic acid every mechanical furnace has been and the two most improved still are patented; that the ammonia soda process and all the electrochemical methods were or are patented; that the patents of Hyatt Bros. founded the pyroxyline plastic industry and every new explosive is patented; that phosphate fertilizers originated in patents and nitrolime and cyanamide are now patented; that the archaic ammonia process is plastered over with petty improvement patents, and that Haber, Frank and Caro and Serpek hold patents on the synthetic methods and products. There are a few other simple little facts inconvenient for the theories advanced in the paper—things that we are invited to overlook in plans for operating on our patent system. We shall try to see whether his oversight is accidental or is inspired by "corporations who have large interests in patented property" like the interest recently shown by a Mr. Berger who tried to have a bill proposed that no patent be granted for anything not already actually in operation (nice for a man of limited means with a dozen alternative processes or machines under one general invention). The paper tells us that *"The industrial and scientific progress of chemistry is to-day carried out in huge establishments by an army of workers, each contributing his share toward the whole."* This may be true of the progress the author is most interested in and represents, but we have a profound reason to be grateful that it is *not* true of the country as a whole. We still have men like Frasch, C. M. Hall, Acheson, Baekeland, W. H. Hall, Wedge, Townsend, Andrews, Ellis, Perkins, Wood, Toch and others far more numerous than the salaried inventors of the "Monopolies or Trusts"—men who have ideas on which new industries can be founded and have the character, the trained ability and the confidence of capital to found and foster these industries to independent success. These are the men who make the nightmare of a onesided chemical industry very unreal to-day and are proving it false for the near future at least. Much as the paper under discussion seems to be antagonistic to monopolies abroad, everything it urges us to do to our patent system means playing straight into the hands of the money powers at home and its recommendations if carried out would go far toward substituting the control by money, either foreign or domestic, for the control by brains fairly and squarely

applied to alien and citizen alike. There are about a dozen large corporations in this country that would for a time profit immensely by the emasculation of the patent system and that openly decry and ridicule the rights granted to inventors. The chief patent counsellors of these companies personally stand squarely for conservative and honest strengthening of the patent system and I would unhesitatingly trust the interests of both inventor and public to the decision of a majority of these men. Their personal consciences dictate their support. But their open and frank support may be quite as useful to the corporations, perhaps more useful than their opposition, for the ignorant public and the legislator shun the very wisdom that these men unselfishly offer. Meanwhile it behooves us, the public, to inquire how far these same corporations are trying to hoodwink the legislator ignorant of actual patent practice, how far they are actually leading him to propose the very destructive measures that are apparently intended to injure the large corporate interests and that would actually serve their best advantage. The majority of the Oldfield patent committee would perhaps be surprised to be considered tools of certain great corporations, but many a tool is quite unconscious of its function or motive power, and every one familiar with existing conditions recognizes the reform measures proposed by these men as being framed perhaps unconsciously in the best interests of the monopolies. "By their fruit ye shall know them." Even the Lenroot "anti-trust" revision of the Oldfield bill (written in by the Patent Committee after the Judiciary Committee threw it out), much as it appears to be a blow at the "trusts," is actually a trust measure tending to abolish the only protection the small competitor has in his livelihood. Any and every form of transgression of any anti-trust law of Congress or of any state, however fantastic, is made the ground for invalidating any patent owned, used, or licensed by the offenders. Inventors cannot even combine for mutual protection of their ideas. Small manufacturers or moderate sized companies cannot buy up additional patents for completion of their patent fences or possibly even employ inventors for that purpose. All that would be needed to invalidate the patent utterly is for the trust to get a license for one machine in one of its plants, or through one of its agents, and then commit or cause to be committed some petty infraction of some petty State law. While red tape and yellow legislation

have already made invention a losing game, these bills would put a penalty on pioneering. The only gainers would be the "Trusts." They need no patent protection. Goliath needs no sword or armour, all he desires is to "get his hands on" David. And our legislators are trying to take away the little fellow's sling and smooth stone —his innovation in the art of war.

We should understand clearly a few things about the so-called "Patent Monopoly," "Product Patents" and this "Compulsory Working" and might as well include "Compulsory License" and "Absence of Price Fixing" also "considered" by our "economists."

You work, and have a right to the fruit of your labor. If you work with another man's materials and tools he has a right to a certain share, but if you work with knowledge and materials common to any one who cares to learn and to use them, if you apply your brains, get a new idea and use materials that you worked for and purchased with which to test the idea or make a model of it, then that new idea (process, apparatus, or product) created for the first time by you is YOURS. You can destroy by forgetting it, give it away, sell it for a thousand million dollars if any one can be induced without deception to pay that price, or you can cherish it as your own secret in your business and no living human being can justly object or legally compel you against your will to give it up to him. No government can grant it to you, because it was originally yours—you created it, or really grant you an exclusive right to it, for if you are truly the first inventor you have that right already, and can keep it unless by chance some one else works the idea out independently for himself (or steals it). Equitably speaking your title to it is infinitely better than your title to real estate given you, inherited, purchased or even built by you, for you have created a new thing, not even copying some other man's method or idea. The right to intellectual property is the most just and fundamental right in this world. The United States first recognized it and on it is based our whole patent system. England granted Royal Patents to support the king on the one hand and on the other to induce the importation of foreign trades, the starting of lines of manufacture not already operated in the Kingdom. The element of invention was unnecessary and incidental.

But even the United States does not actually give intellectual property one-tenth the dignity or security granted to Harrigan's

hog or an old overcoat. All civilized nations recognize the value of stimulating progress by publication of advances as made, of preserving an exact record of progress against accidental loss or destruction, and above all of encouraging progress to practical fruition by giving some one a special inducement to undertake the toil, expense and financial risk of commercializing progressive ideas and educating the people to make use of them. Unless used, an idea is worthless. Experience in Holland without a Patent system and in our own country with inventions dedicated to the public, has shown that the surest way to kill a new idea is to throw it open to everybody. It will not then be worth anyone's while to work out the new thing and educate people to use it, for any one can come along and profit by the first man's planting and cultivating without any such effort or investment of his own.

So the Government—the people as a whole—say to the inventor: "Tell us all about this new thing promptly and fully and we will reward you and aid you and your associates in developing it practically by recognizing your right to it. Some one else might discover it sooner or later and might even develop it, so we can't make your right indefinite, but we will recognize it as yours long enough to make the development of it worth your while and give you a fair reward." The Government doesn't give the inventor a right to his invention—he had that by divine right. The Government (the people) only offers to permit a record of his title and thus save him for a time from the risk of others making the invention also, and give him a public grant so he may have the chance and the inducement to develop the invention, make it commercial and teach the people, provided, however, he tells all about it promptly, and agrees to give up all claim to it in 17 years. In other words, the Government practically buys the invention for the public after 17 years and pays recognition and the right of excluding others for a time in order to induce and enable the inventor and his associates to develop the invention to a thing of public value.

Now, mark you, this service which we are seeking to buy from both the inventor and the investor is like every other service we buy in this world. If we are stingy the service will be niggardly. If we are tricky in our methods and cater to the legal chicanery that is always at the disposal of money power, we discourage and disgust the inventor and the investor, who will simply stop wast-

ing time and money for nothing and either conceal the invention or not even perfect, much less patent it. If we offer good pay, well secured, we shall get good work. And we can't lose in the end. If the invention is good and well protected it will find money to develop it and the product will be sold at the price that will sell it most profitably, *i. e.*, quantity times margin of profit, in 17 years. If the invention is no good we do not lose anything, but if the patent we grant is worthless, no one will touch it, and we have robbed ourselves. Perhaps a monopoly in some related field may take it up, protected by the power of mere size or wealth, but no small manufacturer will be protected in the fruits of his effort. Whatever security we may give the inventor, the invention reverts to us, the public, in 17 years. The only question for us is, shall we inherit a good useful industry or a property that no one has dared to improve because of imperfect title or sterile soil? Such is the "awful monopoly" granted by the Government.

This "product patent" question is, after all, mainly a question of whether we desire to encourage all inventors, rich and poor alike, or only encourage the big corporations and trusts. Only the big fellow who finds a new compound can afford to put 20 men to work at once on all possible ways of making it and pay big attorneys' fees for carefully drawing a dozen patents if need be. The product patent is the poor man's best protection in the U. S.—almost his only good protection with the complicated legal procedure we have here. We have a frequently repeated fallacy that there is no product patent in Germany and that her chemical development is the result. Let us see how it works. The German Law Amendment, 1891, Art. 1, Sec. 2, speaking of patentable subjects, says "exceptions are substances manufactured by a chemical process in so far as the inventions do not relate to a distinct process for manufacturing such articles" and Sec. 4, "If the patent is granted on a process the operation of the same is extended to the direct products of the process." So, if you can afford to employ clever experts and clever lawyers who will study with care the essential steps in the various ways of making the new product and draw a single claim broad enough to cover them all, the *product* of this "distinct process," however broadly expressed, is patentable even in Germany. Quoting directly from the paper in question, "*Of all patents issued to Germans living*

in Germany 75.5 per cent were assigned before issue. The highest ratio of these assignments is reached in carbon dyes, about 98 per cent. Further the paper states *"Of 1754 (total) patents issued for German inventions, 1247, or a little over 71 per cent, related to carbon dyes and compounds and bleaching and dyeing processes, only 5 subdivisions out of 40 considered in the table. The number of those assigned out of 1247 was 1111, or practically 90 per cent, and of these 844, or 68 per cent, were assigned to only 4 companies, who in connection with one other company work on a 'Community of interest' plan, by an interchange of stock and division of profits under an agreement to last 50 years from 1904 —one big trust."* It looks as though the German trusts "got 'em," whatever they are worth, and as though in Germany practically the only inventing worth mentioning (in these lines particularly) was done by employes of the big corporations. What better proof could be desired that the much lauded German system of no product patent is a sweet sop to the big corporation? On second thought you will hardly prefer the German method.

"Compulsory working" has become a farce in every country that tried it except England, where it hasn't been going long enough to become systematized. Elsewhere it is generally a matter of a little money to formally comply with the statute by advertising and laboratory work without really establishing the industry in any true sense, the approximate cost per year in Germany, France, Belgium, Sweden, Italy or Russia being a couple of hundred dollars. England has recently started it. Let us see how, according to statistics, this newest and most drastic compulsory working law has operated during 3½ years. What has it produced? About 50 foreign firms have complied with the law, about 4 million have been thus invested and the yearly pay roll of Great Britain has been increased about 2 million. These figures may appear large but are only 0.1 per cent of the invested capital and 1 per cent of the annual pay roll—an increase of 0.03 per cent and ¼ per cent, respectively, per year. Why, the suffragettes alone cost England much more than this four million dollars last year, in a single year. Some foreign firms would have put up plants anyway and the whole result is practically negligible. But the report goes on to say: "This did not include the large number of licenses granted by the patentees to English manufacturers *under the best conditions obtainable,* choosing the alternative rather

than suffer the repeal of the patent," *i. e.*, patents given away because the new statute had made them practically worthless. Nor does it include the larger number of patents allowed to forfeit and become public property—hence worthless to anyone. Holland had the benefit of the patents of all nations for years but never developed a real industry herself until she passed patent laws to foster it. England is unquestionably doing her industries more harm than good (which as we have seen isn't saying much). Her people will unquestionably be charged the additional price to reimburse those foreigners who started this $4,000,000 worth of factories and she will lose more than an equivalent number of other industries by her confiscating policy. Germany tried the abolishment of compulsory working for U. S. inventors and recently made up her mind to abolish it quite generally, as more harmful than helpful. It will probably take England two hundred years to find this out. Why should we imitate her? Also it is said of France, "Many firms engaged in chemical industry in that country are controlled by foreigners, largely due to the compulsory working feature," as though it were a desirable condition of things to have our business and manufacturing enterprises controlled abroad and sending their profits out of the country. Most of us think not. Probably some protection should be devised against a certain form of abuse—the German patents a product here, supplies our market exclusively by importation, not manufacturing here at all, and charges us an exorbitant advance on the regular price in Germany. A provision modelled somewhat on the Canadian law might help matters, *e. g.*, all patents of foreign invention shall be subject to grant of license to United States manufacturers at royalties to be established by the Federal courts WHENEVER IT CAN BE SHOWN that the product is chiefly manufactured abroad and the price in the United States is more than 10 per cent in advance of corresponding prices in the country of manufacture plus reasonable cost of transportation. This would seem to meet the condition most complained of by the drug and fine chemical trades without unjust confiscation of the inventor's rights. The present situation is, in some cases at least, chiefly our own fault for not contesting strongly enough a grant which really trespasses on the public domain.

Compulsory license would give others the right to sue the inventor or manufacturer for a license whenever the demand was

not fully supplied. The large corporation could create a false demand, storing the goods for a few months. The patentee and manufacturer must increase their plant to meet it or give a license to a powerful competitor. And about the time the added plant is completed, this stored product can be pushed on to the market and both new and old plant held idle for months. Or else, if the license is granted by the court when the new invention is just developing its market and just getting down to a tolerable manufacturing cost, what chance is there of getting a fair royalty? And if the patentee and his capitalist win their suit they would be subject to innumerable suits for granting of license to all others to whom the large corporation cared to lend its legal staff for the purpose. A law against unfair competition has helped to protect pioneers in other countries, but we have no such law. In the U. S. there would be no use in inventing at all or trying to exploit inventions except for employees of the large corporations. In Germany "compulsory license" is to prevent the suppression of vital military, naval or medical inventions by foreigners and there has not been one compulsory license granted in 11 years.

Finally, it only requires the removal of the right to sue as infringement the cutting of fixed retail prices upon patented articles to give the inventor and his manufacturer absolutely no protection against ruin by unscrupulous interests. A few thousand dollars' worth of his goods purchased by the big corporation (or by some jobber at its instigation) and scattered in small lots to the cut rate advertising department stores can utterly demoralize the carefully built up trade and cause the goods to be thrown out by every retailer in the country. And the inventor or manufacturer would have no recourse except to mortgage his factory and spend the proceeds in multicolored litigation under the kaleidoscopic statutes of 48 different states. As it is to-day, all sorts of standard articles of established repute and price (therefore particularly patented articles) are selected as the bait for cut price sales in all parts of the country—sales at which the standard articles (with very few in stock) are largely advertised at 30 to 50 per cent below cost to induce people to come into the store and after which they are persuaded to buy something "just as good of our own make because we have sold all that particular brand," and pay for this substitute twice what it is worth. No surer or quicker way of ruining a business can be devised than starting

the price cutting of its standard product. The consumer always suffers first because price cutting is advertised as a lure to actually sell some relatively worthless substitute; second, it disgusts the retailer of the standard goods who declines to handle them; third, it ruins the business of making good qualities, leaving only the worthless article to cheat the public. The merchants associations themselves favor price fixing (Cong. hearing, Apr. 24, 1912; May 2, 1913; May 16, 1912). Recently the Supreme Court (Bauer v. O'Donnell) decided that the present law gives the inventor no right to sue such pirates as infringers, in other words, no adequate protection. Who is most hurt by this, the "Trusts?" No. The Eastman Kodak Co. is reported to have advised retailers that they must become exclusively Kodak agents or lose the entire line. And they "become," without expense or inconvenience to the Kodak Co. This leaves the small independent more helpless than before, without any similar protection, and we, the public, may go without independent goods. If this is the law, we may well change it.

In considering these four proposals with regard to our patent system, or any others, for that matter, one great fundamental principle should, however, never be forgotten, *i. e.,* the principle of preserving the right and title of the inventive creator to his intellectual property, at least as perfect as the title to chattels for the limited period which is agreed upon as a just and expedient reward for his contribution to human progress. Our prevalent ideas with regard to intellectual property rights are almost aboriginal in their crudeness. With the development of a clearer title to intellectual property, industrial life may look forward to as great a stimulus as social and business life has received by the *securing* of real and personal property right. In the stone age when individual might made right there was little incentive to save or traffic or invest. The world has but recently (about a century) conceived the right to intellectual property in a vague way. Look at the relative industrial advance that has resulted and conceive if you can of the progress when brain property is as secure as real or personal.

Consider: We, the Public, go to the inventor and capitalist to induce the former to reveal his secret knowledge and abandon it to the public in 17 years and induce the latter to put his money into the testing, development, manufacture, marketing, and edu-

cation of customers to use a new and untried invention. We can't reasonably expect this service unless we really give:

1st. A patent obtainable at reasonable cost with the least possible delay and expense of needless technical stickling or the possibility that catchpenny attorneys will abort a patent application to get their money easily. We should further eliminate the enormous delay and expense of interference proceedings, by considering only the first applicant (except in case of fraud).

2nd. A patent that is what it claims to be, a certificate of absolute right in novel property, an agreement between the public and the inventor, his heirs or assigns, "to keep off the grass" entirely for a limited period because he grew the grass; a patent that has been so carefully searched that its presumption of novelty amounts almost to a certainty, and then exposed to public contestation so we all have a chance to object to possible preëmption of public property and practically consent in the grant.

3rd. A patent that, as a certificate of private property, is really enforceable like any other property right by the public that has consented in it after liberal advertising of the proposed grant. If some fellow grabs your pocket book, or automobile, or horse, all you have to do is to make complaint and the People take up the case. All that you have to prove is that he took it. To avoid fine or imprisonment or both he must do all the proving of any right he may have had to take it. There is no reason why properly certified intellectual property should not have equal rights with any other personal property.

All this patent revision work should be in the hands of a Special Commission of diversified character to be selected by the President.

Though larger in number, the patents for mechanical devices that can be imitated are much smaller in value to us, the public, than the processes and products which can be operated secretly or disguised to a very large extent and in the use of which (unless patented) the large corporation can always beat the small manufacturer or the inventor. Public welfare demands that we learn about them all. Without patent protection no small concern or individual will find them worth developing unless they can be kept secret. Public welfare demands the development of industries. We want improvement and progress actually carried out in industries and commerce and not mere paper inventions. Remember

that every cutting down and restriction of the inventor's right for his short exclusive period cuts down the right he is able to give the investor, and that we need the investor's interest in the invention just as much to make real progress. We may trick and bamboozle the inventor, not the capitalist. And remember above all that national interest, integrity and self-respect demand a clear development of the same right to intellectual property as to material chattels. The great IDEA is quite as valuable and dignified as the great American Hog.

No truer word was ever spoken of our industrial progress than the oft-quoted statement of Kaiser Wilhelm to the late Henry W. Draper, "There are three causes for your (American) wonderful industrial progress; your native ingenuity, your great national resources and your admirable patent system. But the greatest of all is your patent system." Lately, however, our patent practice has become wound up in legal red tape until it has almost lost stimulative effectiveness; our resources have, until recently, been thoughtlessly squandered, and our native ingenuity is better evidenced by variety and multiplicity of proposed laws and cunning methods of avoiding them than by simplicity and obedience. And now there has arisen a new madness from within and a new menace from without. Within, our restless ingenuity for legislative blunders in turning its attention to the patent matters refuses to see the need of a Commission of legal, technical and business experts and ardently pursues any phantom reform that threatens to emasculate the whole system. Abroad, the recently adopted patent law of Holland is already bearing fruit in industrial development where the greatest merchandizing nation of history is prepared to bring the products to our shores. Germany, with eminent advice from all classes interested, is remodelling her already excellent and simple patent laws to surpass our own. Japan, with 50 million population and very cheap labor, now has a well studied and carefully executed patent law in some respects better than our own, and is developing wonderfully her industries, and China will before long turn her 400 million thrifty people and very great natural resources, including enormous coal fields, into competitive industry.

Manufacturers of the United States, unless you look around you and look ahead, no tariff will protect you long with certainty. The people at large insist on having the world's products at a fair price and if you neglect your birthright it will be another's

to make these goods. The people may vacillate in their opinion, but that is industrially worse than continuous free trade. Without the stimulous to your own country's brains which security of intellectual property rights alone can give, you will as surely run down to stagnation as the unwound clock. The inventor and the investor in new inventions, alone can keep our industries in the van of progress. We may fool the inventor with insecure patents but not the investor, and we need the investor just as much as the inventor and must make secure the rights of both. If you sit idly by and suffer chromatic legislation to emasculate the patent system the ingenious legislators will write the death warrant of your industries and your business. And, mark you, it avails you little to make steel, or clothes, or some other thing "not based on patents." The success and prosperity of the country at large are the real foundations on which your prosperity rests and the failure of the man who needs your steel or the man who weaves your cloth or buys your clothes will carry you down with him. If "it only hurts the other fellow's business, not ours," you cannot avoid your part of the penalty brought by destruction or degeneration in other lines of industry.

One of my former clients shrouded and laid away his business some years ago because German invention had outstripped him in more than half his products. The president of another client told me recently that Japanese products were beginning to be offered his customers at little more than half what it *cost* him to make them. Why not, with ample supply of cheap raw material in China and Japanese labor at 15 cents a day? He "had never thought much of patents," but confessed "I wish we could protect our products to-day." You manufacturers may not see what good a simple, easily enforced patent system would do you directly to-day; most of you do not realize that almost any material advance you make in an art, is protectable if properly presented by really good patent attorneys (none of whom by the way is any cheaper than the really successful lawyers in another line). To-morrow may bring that special improvement in method or quality of product that would help to assure the safety of your business for 17 years, if your right to intellectual property were secure. Next year is as likely as not to establish beside you a new industry that for 15 years will supply a new and cheaper material for your plant or else take the greater part of your out-

TABLE I

Patents Relating to Principal Chemical Manufactures Taken Out in the United States During 1900–1910, According to Nationality of Patentee and Ownership of Patents

	Totals.		Total Foreign	America.		United Kingdom.		France.		Germany.		Switzerland.		Europe, all Other.		Foreign, all Other.	
	Total Patents.	Number Assigned.	Total Patents.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.
Grand Totals	4068	2087	2516	1552	524	212	46	178	29	1754	1324	167	146	162	9	43	9
Division III.																	
Class 204; Electro-Chemistry: Subclasses—																	
18. Alkalies and Chlorine	115	41	45	70	30	13	1	4	..	4	2	2	..	16	6	6	2
59. Bleaching and Disinfecting Liquors	30	14	20	10	8	4	1	1	..	12	5	2	..	1	..	..	..
60. Chlorates	11	4	7	4	1	1	..	2	..	1	1	1	..	..	..	2	2
51. Dyes and Pigments	22	13	3	19	11	..	..	..	..	..	..	2	2	..	..	1	..
62. Carbids	73	42	14	58	39	3	..	2	..	3	1	..	..	4	..	2	2
27. Tanning	5	3	..	5	3	..	..	..	..	..	..	..	..	..	..	..	..
Total	256	117	89	167	92	21	2	9	..	20	9	7	2	21	6	11	6

DIVISION VI.																	
Class 9; Bleaching and Dyeing: Subclasses—																	
1. Carbon Dyes	862	819	843	19	9	11	5	11	4	701	685	115	113	5	3	..	..
2. Bleaching	50	16	30	20	5	8	..	3	..	17	11	..	..	2	..	..	..
5. Dyeing Processes	141	70	110	31	10	8	1	9	3	79	56	..	..	14	..	..	..
6. Dyes	38	15	16	22	5	3	..	3	1	10	9	..	..	..	..	..	..
20. Mercerizing	53	7	29	24	4	11	1	3	1	10	1	..	..	5	..	..	..
13. Mordants	43	12	21	22	5	2	1	3	..	13	6	..	..	3	..	..	..
Total	1187	939	1049	138	38	43	8	32	9	830	768	115	113	29	3	..	..
Class 23; Chemicals: Subclasses—																	
1. Acids, mineral	215	77	99	116	41	8	3	6	..	62	32	1	1	21	..	1	..
5. Fire extinguishing compounds	13	5	8	5	1	1	..	1	..	4	4	..	..	1	..	1	..
Catalytic bodies	17	9	12	5	2	..	..	1	..	10	7	..	..	1	..	..	..
10. Metalloids	86	29	31	55	23	5	..	9	1	14	5	..	..	2	..	1	..
11. Packing Chemicals	14	6	4	10	5	1	..	1	..	2	1	..	..	..	..	..	..
3. Apparatus	61	11	21	40	10	7	1	..	..	10	..	..	..	3	..	1	..
13. Salines	337	118	191	146	51	43	15	16	2	98	50	3	..	21	..	10	..
21. Ammonia	47	13	41	6	1	8	5	1	..	27	7	..	..	4	..	1	..
22. Soda and Potash	42	12	18	24	7	1	..	3	..	9	5	1	..	3	..	1	..
24. Carbon compounds	685	448	555	130	51	18	3	38	10	450	359	32	25	16	..	1	..
Total	1517	728	980	537	192	92	27	76	13	686	470	37	26	72	..	17	..
Class 52; Explosives: Subclass—																	
3. Nitro-compounds	156	61	59	97	55	14	1	8	..	28	5	..	..	8	..	1	..

TABLE I—*Continued.*

	Totals.		Total Foreign.[1]	America.		United Kingdom.		France.		Germany.		Switzerland.		Europe, all Other.		Foreign all Other.	
	Total Patents.	Number Assigned.	Total Patents.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.	Total Patents.	Number Assigned.
Class 167; Medicines: Subclasses—																	
5. Hair Dyes and Tonics	20	2	4	16	1	..	..	..	..	2	1	..	..	..	..	2	..
4. Extracts	82	16	38	44	6	8	2	4	..	18	6	..	..	6	..	2	2
9. Topical Remedies	71	19	26	45	10	2	..	..	..	20	9	1	..	3	..	..	..
7. Internal Remedies	89	41	66	23	6	2	..	4	2	52	31	2	1	3	..	3	1
6. Insecticides	81	9	12	69	8	2	..	..	..	6	..	1	1	1	..	2	..
3. Disinfectants	306	68	66	240	57	10	..	25	2	19	9	..	..	7	..	5	..
Total	649	155	212	437	88	24	2	33	4	117	56	4	2	20	..	14	3
Division XV																	
Class 106; Plastic Compositions: Subclasses—																	
37. Pyroxylins	43	10	23	20	4	2	1	9	1	10	3	2	1	..	..	..	..
40. Viscose and Cellulose	59	25	42	17	9	5	4	4	2	28	9	1	1	4	..	..	..
Total	102	35	65	37	13	7	5	13	3	38	12	3	2	4	..	..	..
Class 18; Plastics: Subclass—																	
51. Pyroxulin	14	10	2	12	9	1	..	..	..	..	..	1	1	..	..	..	..
Division XXXI.																	
Class 87; Oils, Fats, and Glue: Subclass—																	
7. Glue	23	6	11	12	5	1	..	1	..	8	1	..	..	1	..	..	..

Class 134; Liquid Coating Compositions: Subclasses—																		
72. Treating Lead Salts	4	..	2	2	..	2	..	..	..	..	..	..	..	..	..	..	..	
54. Paint-rubber	9	1	2	7	..	..	..	..	..	1	1	..	..	1	..	..	..	
17. Rubber	6	3	2	4	2	..	..	..	..	1	1	..	..	1	..	..	..	
59. Iron Salts	13	1	2	11	1	..	..	1	..	1	..	..	..	..	..	..	..	
60. Lampblack	16	2	8	8	2	..	..	1	..	7	..	..	..	..	..	..	..	
67. Lead Salts	18	7	4	14	7	2	..	..	..	1	..	..	..	1	..	..	..	
77. Ultramarine	2	..	2	..	..	..	..	2	..	..	..	..	..	..	..	..	..	
78. Zinc Salts	39	7	12	27	6	4	1	1	..	5	1	..	..	2	..	..	..	
79. Pyroxylin	14	4	7	7	3	..	..	1	..	4	1	..	..	2	..	..	..	
Total	121	25	41	80	21	8	1	6	..	20	3	..	..	7	..	..	..	
Class 203; Ammonia, Water and Wood Distillation: Subclasses—																		
1. Ammonia, including Turpentine	13	2	6	7	2	1	..	..	..	5	..	..	..	..	..	..	..	
4. Turpentine Processes	17	6	2	15	6	..	..	..	..	2	..	..	..	..	..	..	..	
3. Turpentine Apparatus	13	3	..	13	3	..	..	..	..	..	..	..	..	..	..	..	..	
Total	43	11	8	35	11	1	..	..	..	7	..	..	..	..	..	..	..	

put for its special use. And the special use of the new material or adaptation of your product is almost sure to be wholly or in part protectable by patent. Will you take title to the intellectual property that is really yours or merely be a squatter till foreign competition (if not domestic), till cheaper labor or better stimulated brains can drive you out?

Your only permanent safety in the future lies in the preservation and perfection of the U. S. Patent System, for the only sure stimulus to effort is security in the fruits of effort.

No temporary "influence on legislators" will stem the tide. It worked for a few years with the tariff but, within ten years after direct popular education on tariff matters gave place to political jobbing, the mass of people ceased to understand. Where is there any assurance of protection to-day? Whatever new idea you conceive that improves your process or the article you manufacture, should be as much yours as an overcoat you buy: Your title should be as clear and simple and well recognized for a reasonable time and your right to protection by public prosecution at least as good as if some one stole your overcoat. A few of us are trying to educate 90 million people to understand that the future of this nation and their own individual prosperity depend directly on the security of intellectual property. You would do well to start the regular education of your workmen, for it is the uneducated vote that puts in the destructive legislator. Your Board of Directors had best appoint their brightest man a "Patent Committee with power" to lend a hand. Get an intelligent Commission, have its findings published broadcast for discussion so the average voter may understand the issue and the Congress dare not ignore anything the Commission recommends.

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DISCUSSION.

Dr. Grosvenor: Before being called upon to read this paper, I hoped that the President had overlooked it. This paper was not written with a view to being read; it was distinctly a paper intended for publication and circulation in connection with our Patent Committee work. About a year ago a statistical paper was read before the Society in New York, entitled "Patents and Chemical Industry in the United States." At that time, it was not thought to require

serious discussion. While clauses in it struck some of us as being a little unsound it did not seem entirely just, on account of the valuable statistical work done, to criticize the paper. Since then, however, it has been published and has received a great deal of comment. We are, therefore, taking it up specifically for discussion.

The conclusions were based on the number of patents issued. The author considered our chemical industry backward, and this paper will, I think, serve to refute it. A lot of statistics are given showing decrease of imports and a very large increase of production, but I do not think you would feel like discussing them at this time.

One point, however, is worth considering here and I want to emphasize it. That is the general relation between the manufacturer and the patent and more specifically the manufacturer's need to look a little bit forward and take precautions. Holland, not so many years ago, started out in the patent industries and their growth has been surprising. Germany revised her patent laws and in some respects they are very much better than ours. Japan's patent industry has increased and China is coming forward as a civilized nation with a population of some 400,000,000. Our manufacturers in the United States might as well face one fact, brought home to us in the last year or two, namely that we cannot always rely on the "stone wall" surrounding our industries. If it is to be "knocked down" and "set up," this is worse than having it knocked down all the time. Thus it seems we have come to a point where our industrial progress in the long run needs something to insure us from invasion from other countries of cheap labor and raw material. I think the time has passed when we can for years continuously rely on tariff protection because our people are reaching the point where they want the world's goods at the right prices and, if we do not manufacture them cheaper than the other fellow does, why we must let down the fence and let them come in. The only way in which our industries can be made continuously profitable is progress, and the only protection for the fruit of progressive effort is the patent system.

Most people do not realize how slight an improvement in industry will affect progress, and how frequently the improvement at first sight apparently small can be well protected by patents. We must bend every effort to making a U. S. patent what it purports to be—a title to property. If anyone steals your overcoat you can com-

plain to the police and get redress—if anyone steals your intellectual property, there is very poor means in this country to protect it. The Institute should take the lead in this educational movement.

If anyone is going to do anything, it is up to the Institute to do it. In every way the individual members of the Institute can bring before their corporations the need of means to this end and help the educational policy we are striving to carry out.

Dr. WAGNER: Any discussion of this very interesting paper, which I am very glad was allowed to see the light of day.

One statement made by Dr. Grosvenor—that the subject of patents has not found recognition among the public of this country as much as abroad for many years is quite true from my own experience. Abroad the patent is looked upon as an asset, and the inventor is known as a benefactor, but every patent is looked upon here as a scheme.

I should be very glad to hear regarding this.

Dr. HEBDEN: I would like to ask Dr. Grosvenor what he and the other members of the Committee on Patents think about the English working clause—whether they believe in it or not.

Dr. GROSVENOR: Perhaps I can answer that a little more clearly by asking you to read the paper, as that is one of the points discussed in this paper—one of the things that we ask you to consider, and it is one of the points we want to take up. We believe "compulsory working" is not conducive to originality,—that is, compulsory working discourages invention and progress.

Dr. HEBDEN: Compulsory working of patents is being used in England—the law there provides that in the case of a patent taken out by the manufacturer that, if at the end of two years, 80% of the patented material is not manufactured in England, the patent can then be declared void—they give them two years in which to prepare to manufacture, and if the manufacturer sells more than 20% of material manufactured abroad under the patent in England, the patent can be declared void. The theory seems to me to be sound. In giving protection under a patent in a country, you give it because a man has created a new industry where none existed before and he should have the protection, but under the assumption that he has created a new industry in the country where the patent is issued. It does not seem fair that a man in England should have a monopoly while the manufacturers in America are not protected, and England is benefiting by it.

He ought to be allowed to make money out of it but be obliged to manufacture it in the country in which the patent is issued. I think this is where we have been having trouble with the Germans in aniline dyeing as they have patented everything and refuse the license in this country for manufacture here and they have protection under our patent law and German workmen and people benefit from it. Since those patents have expired, the prices by the Germans have been put down to such a low point that no one in this country can afford to manufacture the articles. Men going into the business here and starting afresh would find that Germany would very quickly reduce them for the time being by selling about 10% below cost and keep the price there until they went out of business—oil and salts for instance. I feel very strongly about this and would like to know what the feeling is.

DR. GROSVENOR: I think the feeling is that theoretically speaking the criticism is a sound one, but the remedy would practically have to take a form which no one yet has been able to determine if it is not to be subject to very serious dangers. That particular method used abroad, by cancelling patents, is the worst method that could be selected. If the patent is cancelled there will be no industry there. This is something which has proven universally true in many places, in Switzerland, later in Holland, and last in Japan. In the U. S. it is proven by the fact, generally recognized, that a patent thrown open to public use is nobody's property, because it is anybody's.

What actually happened in England is that since the law went into force they have built about $4,500,000 worth of factories and increased the yearly pay-roll about that much. In the aggregate, the effect on English industries has been practically nothing.

If we were dealing with a patent on a product which was a staple article of recognized use, like the old English Crown patents under which part of the profits went to the Crown, we would feel very differently about it. Everybody knows the goods, needs them, knows how to use them. But dealing with a new invention, something every man does not want and has to be educated to use,—sometimes you have to take him and cram down his throat. With safety razors, they had to wean men from the old standard. Now you could not make men do without them, but originally someone had to be secured in his profit before he would undertake to educate the race. It is the same story again and again in the educational

campaign. If we took the stand to-day of cancelling every form of patent, the result would be that many industries that otherwise would be taken up here and our markets developed, would be dropped because no one could afford to develop a market for the benefit of some other fellow.

I know of one instance where a new product is to-day placed in exactly that situation in Canada. We have a product where we have to go into a man's plant for two weeks or so in order to teach him to use it, even though it would save him largely in the end. It is better to put a man in the factory for weeks and sit by the job with him than to let him experiment with it alone. In Canada we cannot put up a factory yet. We are not prepared to go in and educate them *all* at once. The consumption is being gradually increased but, in the meantime, our year for importation has expired, whereas it will be five years, doing the best we can do, before it will be worth while to put up a factory for that market. The way of cancelling the patents is a distinct setback to industry.

Dr. WAGNER: I presume Dr. Grosvenor you have answered Dr. Hebden's question and that it has been solved.

Dr. GROSVENOR: The question was what the position of the Committee was, and I think I have answered it. The compulsory license which is obtainable in Canada is more wise. A man who has a product that can be so handled may open it to compulsory license in Canada. The industry does not suffer so much under this and it is to a man's interest to do it. This is the best solution we have seen, *but* it has not been very helpful as yet, for it is almost a dead letter.

Dr. WAGNER: This would not help much on aniline dyes.

Dr. GROSVENOR: I think what would actually happen if we had the working clause is that we would see branches established in this country. Two of the largest representative concerns told me that when this matter was under consideration they had plans practically completed for establishing a large aniline industry here, and were prepared to do some very successful work but they succeeded in bringing about a patent convention between the U. S. and Germany which provided that no working law be made in this country—between Germany and the U. S.

Dr. HEBDEN: I would like to call one point to the attention of those present in connection with the color process in Great Britain which is, as you know, really the home of the color industry and for many years one of the first which went into the business.

Great Britain has produced more than 80% of the raw materials entering into the manufacture of dyes. I know of one case where they tried to prevent the manufacture of color in Great Britain, and in return for selling to Germany and France, Great Britain imported in finished product 80% of the dyes used. I never could figure this very good business and think it is one question which should be looked at in the light of the experience of Great Britain and that if we hope to manufacture colors here we must have some inducement.

Dr. Grosvenor: That feeling is just why that matter was taken up—it is a very great tempest in a very, very small demi tasse. Take our chemical production of 1912, ($1,400,000,000) what does $9,000,000 worth of dyes amount to? We do not pay very high prices for our dyes. The total amount of them does not figure up but a bagatelle in the cost of our work, and any risk which we take with the vital patent system is incomparably more important than whether we make the dyes or not. I am told that a very considerable number of dyes are actually manufactured at a loss. What is your idea?

Dr. Hebden: I do not know.

Dr. Grosvenor: One other feature to consider is that, if these works are to be owned and controlled abroad, whatever profits are made from them (if the industry is worth while) will go abroad. This is the condition which is considered in France to result from the working clause. While it is true that if made here, all that would be sent out would be a profit and we now send not only the profit but the whole cost, yet there is a balance of trade that for some reason seems to offset that as far as we can find out. If we manufacture other goods here and send them abroad, we may well buy these goods from abroad. If we actually withdraw money as profits from industry here, it is spent abroad somewhere. The merchandise circulates back and forth. I understand that while $9,000,000 worth of dyes came into this country about $15,000,000 profit was made from them after importation into this country, and most of this spent here.

Mr. Adamson: Fifty per cent of the coal tar and coke we burn in this country.

Mr. Howard: I do not think that we should underestimate the importance of the aniline and coal tar industry. The chemical industry in Germany has depended on the color industry, this is

what gives them their profit. Three of the largest companies—I do not know how much money they make on any one product—but they have dividends of from 25 to 35%.

Dr. GROSVENOR: Have you ever chanced to go over the business records to see where the profit came from—why they were so interested in the manufacture of a number of different dyes? The Standard Oil profits are not made out of oil entirely to-day—it used to be but not to-day. It is made from specialties as well as from the regular manufacture. One single dye that I understand was consumed in larger quantities than any other used in the United States is a blue glue that is manufactured here.

Dr. ITTNER: Are you sure it was not ultramarine?

Mr. HOWARD: I do not know what the blue dye referred to can be, and I doubt very much whether any dye is manufactured in the United States in the quantities indicated. I heard a rumor in Washington of something of this sort which had been mentioned for purposes of influencing legislation but which on investigation amounted to nothing.

Mr. JONES: I also would like very much to know the name of this blue dye as, from the dyer's point of view, it would be decidedly interesting. As a matter of fact there is far more black used in the United States than of any other one color, so that the statement seems hardly justified.

Dr. GROSVENOR: I do not know how far I am at liberty to discuss the matter but I believe the information conveyed is undoubtedly correct. If the gentlemen who are interested will let me have their names I shall endeavor to secure permission to advise them in detail as to the facts. (The Bayer Company of New York City, manufacture in Albany very large quantities of so-called soluble blues, alkali blues, and of nigrosines and chrysoidines, most of which are also manufactured by the National Anilin & Chemical Co. They understand that the quantities of nigrosines and soluble blues manufactured in the U. S. by far exceed the output of these colors in Germany to-day, and they know that the nigrosines of American origin are exported to Europe. They also manufacture in Albany a good deal of chrysoidine and Bismarck brown. The raw materials for these manufactures (anilin oil, etc.) have so far been imported.)

THE EFFECT OF CLIMATE ON PLANT LOCATION.

By WM. M. BOOTH.

Read at the Boston Meeting, June 25, 1913.

At the Detroit meeting of the Institute, I suggested certain data that should be obtained and considered before a manufacturing site is chosen. One of these sub-divisions was "climate." Altho

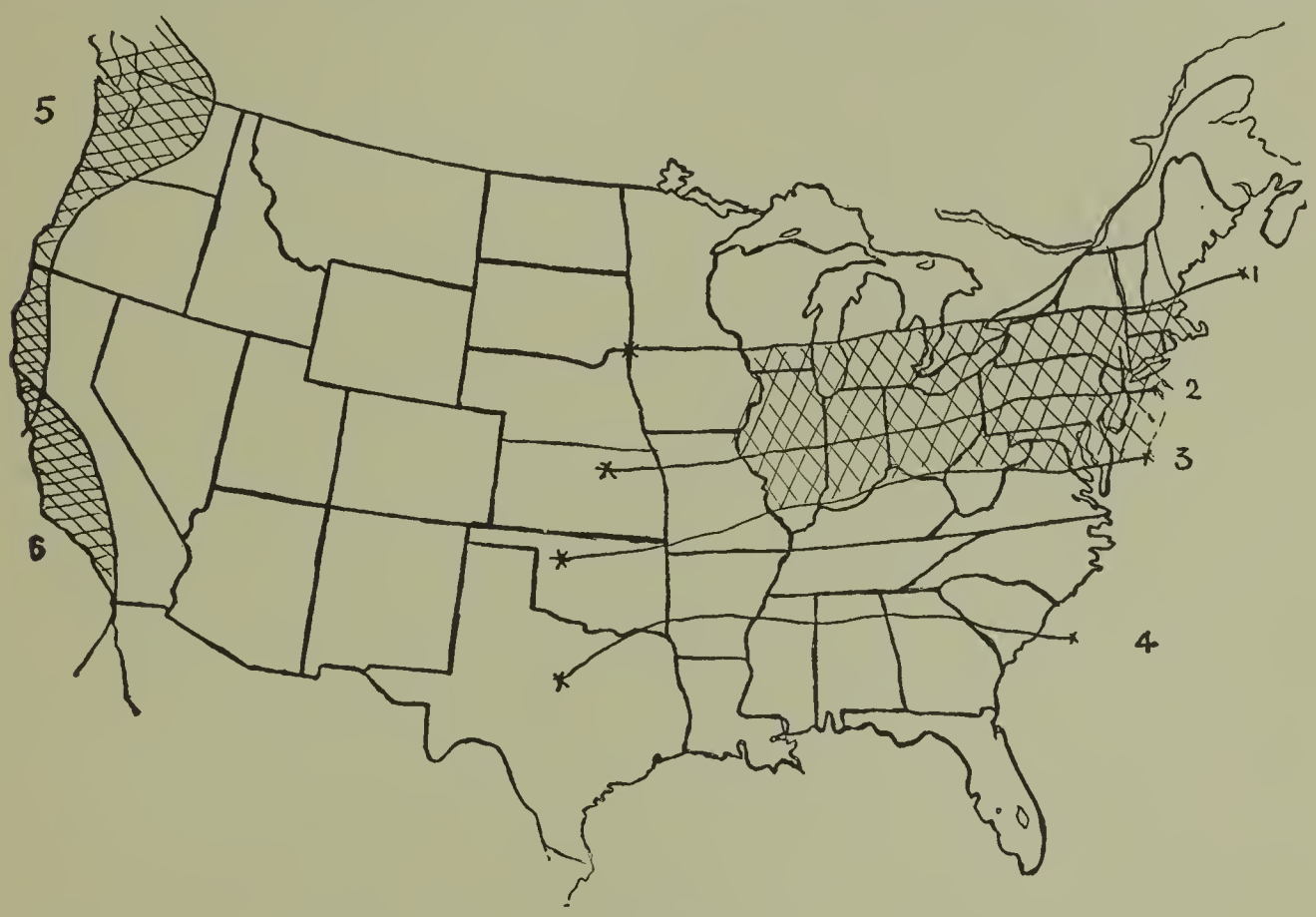


CHART 1.

Nos. 1 to 3. Main manufacturing belt of the United States.
No. 1. Manufacturers suffer annually from ice and snow from January to April.
No. 2. Most favored section for miscellaneous manufacturing in U. S.
No. 3. Southern boundary of intensive manufacturing belt.
Nos. 1 to 3. White labor predominant.
Nos. 3–4. White and colored labor.
No. 4. Black labor necessarily predominant.
No. 5. Available manufacturing belt of Pacific Coast for white labor.
No. 6. Manufacturing belt employing Chinese, Japanese, Malays, Hindoos, and Mexicans

not of primary importance in many industries, some lines of manufacturing are absolutely dependent upon atmospheric conditions and all are influenced in some degree, directly or indirectly, by daily and seasonal changes.

To broaden the scope of this inquiry beyond personal observation or academic discussion, I prepared a circular letter which was sent to one hundred manufacturers in various parts of the

United States. Forty replies have been received, more than thirty of which conveyed information useful to us in this discussion. These replies are summed up as follows:

TABLE I.—EFFECT OF CLIMATE ON "GOING" PLANTS

Name of Company.	Location.	Business.	Climatic Effect.
West End Paper Co.	Carthage, N. Y.	Paper Mnfg.	Troubled by anchor ice.
Oswego Falls Pulp & Paper Co.	Fulton, N. Y.	Paper Mnfg.	Moist, cold air interferes with drying paper.
Hammerville Paper Co.	Erie, Pa.	Paper Mnfg.	No difficulty.
Hoffman, Ahlers, & Co.	Cincinnati, C.	Copper apparatus.	No difficulty.
Waltham Watch Co.	Waltham, Mass.	Watches.	Rust and dust both affect this business.
Name withheld.	Connecticut.	Brass castings.	Loss of about one week per year in foundry, due to heat.
Lackawanna Steel Co.	Buffalo.	Rails and merchant iron.	No effect on production.
Jeffrey Mfg. Co.	Columbus, O.	Conveying machinery.	Hot weather loosens belts; ice and snow accumulate on industrial railway about works.
Gen. Elect. Co.	Schenectady, N. Y.	Electric apparatus.	Moist air difficult to exhaust from incandescent bulbs.
Deere & Co.	Moline, Ill.	Agricultural implements.	No effect.
Welsbach Lighting Co.	Gloucester City, N. J.	Gas mantles and appliances.	Action of extreme heat on employees.
Name withheld.	Syracuse, N. Y.	Metal parts Japanned.	Lose luster when shipped during cold weather.
Beechnut Packing Co.	Canajoharie, N. Y.	Food products.	Effect of frost, early and late.
Name withheld	Central N. Y.	Canned goods.	Extreme heat on employes, early and late frosts on corn and pumpkins.
Bausch & Lomb.	Rochester, N. Y.	Lenses and microscopes.	Heat loosens lenses on grinding machines; cold contracts; both tend to produce imperfect lenses. Wind cools one side of factory excessively.

EFFECT OF CLIMATE ON "GOING" PLANTS.—*Continued*

Name of Company.	Location.	Business.	Climatic Effect.
Standard Spinning Co.	Oswego, N. Y.	Combed and carded cotton.	Temperature and humidity absolutely limit the location of such a plant. Oswego very favorably situated for such a business.
Name withheld.	Central N. Y.	Woolen cloth.	Freezing of water in pipes, anchor ice, fog in dye house.
Solvay Process Co.	Syracuse, N. Y.	Alkali, coke and tar products.	Quarry work hindered or stopped by snow and ice. Coke ovens difficult to operate due to freezing of pipes. Wind causes excessive radiation. Cold water very essential to coke and alkali industry for cooling purposes. Humidity prevents dust explosions in coal mines. Ice in slack coal prevents shipping same north during winter. Rain and snow tend to fire coal packed in piles.
Semet Solvay Co.			
R. K. Meade.	Baltimore.	Cement Mfg.	Ice in quarries; cold weather lowers sales of cement.
Name withheld.	Southern California	Beet Sugar.	Influenced by rainfall, winds and frosts.
C. A. Tripp.	Indianapolis, Ind.	Consulting engineer.	Mfg. of gelatine-medicine capsules absolutely dependent on condition of air; likewise effervescent salts, hypodermic tablets, chocolate and lard.
Name withheld.	Central N. Y.	Photographic supplies, films and plates.	Must use air free from smoke and dirt.
National Ammonia Co.	Frankford, Pa.	Anhydrous ammonia.	No effect on this business.
Naugatuck Chemical Co.	Naugatuck, Conn.	Chemicals.	Extreme heat not particularly favorable.
Henry Bauer Chemical Mfg. Co.	Philadelphia.	Tin salts, ammonia prussiates.	No effect on this business.

EFFECT OF CLIMATE ON "GOING" PLANTS.—*Continued*

Name of Company.	Location.	Business.	Climatic Effect.
Davison Chemical Co.	Baltimore.	Sulphuric acid.	Warm weather limits production of acid by dissolving lead and condensation of nitre gas in towers becomes difficult.
Name withheld.	Central N. Y.	Enameled leather.	Drying leather hindered by cold and lack of sunshine, preventing chemical action.
Harrison Bros. & Co.	Philadelphia.	Heavy chemicals and paints.	Can make more sulphuric acid during cold weather; colors work up better; lactic acid dept. runs better in summer. Belts stretch excessively during hot weather.
Dow Chemical Co.	Midland, Mich.	Chemicals.	Process work very dependent upon temperature and humidity.
Western Chemical Co.	Denver, Col.	Heavy chemicals.	Altitude a serious handicap.
Pennsylvania Salt Co.	Philadelphia.	Mfg. chemists.	More difficult to produce chloride of lime in summer.

The labor incident to a study of climate is very much lightened by systematic and reliable observations that have been recorded by government officials for more than thirty years. These records cover nearly every type of climate in the United States. I have collected numerical values from the main office station records and present these in Table II. It will be seen from these that our discussion includes rainfall, humidity, temperature, barometric pressure, sunshine and wind velocity; measured by the thermometer, hygrometer, barometer, rain gauge and anemometer.

RAINFALL.

Broadly speaking, we have a useful and normal rainfall east of the Mississippi river. From this point westward, thru Kansas, Nebraska, Colorado, Wyoming and Utah, the annual precipitation gradually diminishes from forty inches to zero in the desert areas.

The northern Pacific states are well watered while the western coast of the state of California has a low rainfall.

Altitude.

The altitude of manufacturing cities pretty generally increases from New York to Chicago and diminishes from this point to the Gulf of Mexico. The elevation is, however, but a few hundred feet and does not appreciably hinder or accelerate industrial processes. The difference between the average barometric pressure at New York and Chicago is .516 inches. With the exception of Atlanta and the cities of central Tennessee, southern manufacturing centers are in low altitudes.

As one approaches the Rocky mountains from the east or south, the altitude rapidly increases and an extremely low barometer makes itself felt in every form of industry. Water boils in Denver at 94.7° C. or 202.56° F. and it is almost impossible to cook certain vegetables. The barometer stands at 24.7 inches on a fair day and a 28 inch vacuum is an imaginary ideal.

Immense mining properties are operated further back in the mountains at altitudes of from 8000 to 12,000 feet, where water boils at 90° C. or 194° F. and where the barometer stands normally from 22 to 19 inches. Puzzling operating difficulties are met, unknown to eastern engineers. Extreme altitude offers few advantages to the manufacturer and exacts unusual precautions.

After passing the Salt Lake plateau also high up, we come to the coast cities, San Diego, Los Angeles, San Francisco and Seattle at tide water level, and Portland on the Willamette River, practically so.

Humidity.

Water vapor in the air and the discussion of its effect is one of the main object of this paper. Table II, Col. 2 shows the mean annual humidity of most of the large cities of the United States. This climatic factor is normal excepting in a few extremely damp locations along the coast, at extreme altitudes, or over desert areas where the quantity of the moisture in the air is extremely small.

Temperature.

Practically all parts of the United States excepting mountain peaks and northern Vermont, New Hampshire and Maine are

TABLE II.—CLIMATIC CONDITIONS IN THE UNITED STATES.

Location.	Rainfall. In.	Mean. Rel. Hum. %	Max. Temp. ° F.	Min. Temp. ° F.	Av. Temp. ° F.	Av. Bar. Ins.	Boiling Point Water. ° F.	Alt. Ft.	Av. Vel. Wind. Mi.	Sunshine. %
Albany, N. Y.	36.9	76	104	−24	48	29.878	211.93	23	6	54
Amarillo, Tex.	21.9	60	105	−16	55	26.248	205.46	3576		
Atlanta, Ga.	49.9	72.5	100	− 8	61	....	....	1052	9	61
Augusta, Ga.	48.5	74	105	+ 3	64	29.838	211.85	108		
Baltimore, Md.	43.4	70	104	− 7	55	29.868	211.90	103	..	58
Bismarck, N. D.	18.8	69	106	−44	40	28.222	209.06	1672	9.6	57
Boise, Idaho	12.9	58.5	107	−28	51	27.173	207.18	2706	4	61
Boston, Mass.	43.7	72	102	−13	49	29.824	211.83	15	11.3	55
Buffalo, N. Y.	37.4	73	95	−14	47	29.152	210.67	612	11.1	49
Cairo, Ill.	41.6	74.5	106	−16	58	29.662	211.55	313		
Charleston, S. C.	53.4	78	104	+ 7	66	29.992	212.11	11	..	56
Chattanooga, Tenn.	51.6	74.5	101	−10	60	29.254	210.85	700	6.	55
Cheyenne, Wyo.	13.1	54	100	−38	45	23.998	201.12	6056	..	65
Chicago, Ill.	33.4	75	103	−23	48	29.129	210.64	595	9	57
Cincinnati, O.	38.4	69	105	−17	55	29.360	211.03	553	7.6	56
Cleveland, O.	35.6	73	99	−17	49	29.182	210.74	659	9	45
Columbus, O.	37.2	73	104	−20	52	29.143	210.66	759		54
Denver, Colo.	13.7	50	105	−29	50	24.720	202.56	5219	7	69
Des Moines, Ia.	32.4	72	109	−30	49	29.103	210.59	806	..	60
Detroit, Mich.	32.2	75	101	−24	48	29.206	210.77	593	9	52
Duluth, Minn.	29.9	75	99	−39	..	29.236	210.82	702	7	
Eastport, Me.	43.4	78	93	−21	42	29.848	211.87	33	9	49
El Paso, Texas.	9.3	39	113	− 5	63	26.166	205.31	3702	5	
Erie, Pa.	39.2	76.5	94	−16	49	29.222	210.79	659	..	45
Galveston, Texas.	47.6	85	98	+ 8	70	29.946	212.04	6	12	60
Helena, Mont.	13.3	56.5	103	−42	43	25.798	204.62	4109	6	56
Indianapolis, Ind.	41.9	70.5	106	−25	55	29.142	210.66	711	..	54
Jacksonville, Fla.	53.4	79	104	+10	69	29.987	212.10	43		60
Kansas City, Mo.	36.4	70	106	−22	54	29.009	210.42	779		57
Keokuk, Ia.	35.1	69	108	−27	51	29.352	211.01	505	8	52
Knoxville, Tenn.	49.7	74	100	−16	57	28.986	210.40	992	5	56
Little Rock, Ark.	49.6	72	106	−12	62	29.654	211.53	299	..	64
Los Angeles, Cal.	15.6	71	109	+28	62	29.619	211.47	286	..	73
Louisville, Ky.	44.5	67	107	−20	57	29.470	211.22	460	7	58
Marquette, Mich.	32.4	78	108	−27	41	29.191	210.74	656	11	
Memphis, Tenn.	50.8	72	104	− 9	62	29.629	211.49	268	6	61
Milwaukee, Wis.	31.0	75	100	−25	45	29.277	210.89	619		47
Mobile, Ala.	62.1	81	102	− 1	67	29.981	212.09	12		
Montgomery, Ala.	50.8	73	107	− 5	66	29.803	211.80	222	5	
Nashville, Tenn.	48.6	71	104	−13	59	29.476	211.23	459	6	60
New Haven, Conn.	47.2	75	100	−14	50	29.856	211.88	25		50
New Orleans, La.	57.6	77	102	+ 7	69	29.978	212.09	8	7	53
New York, N. Y.	44.8	73.5	100	− 6	52	29.645	211.52	37	9	56

CLIMATIC CONDITIONS IN THE UNITED STATES—*Continued.*

Location.	Rainfall. In.	Mean Rel. Hum. %	Max. Temp. ° F.	Min. Temp. ° F.	Av. Temp. ° F.	Av. Bar. Ins.	Boiling Point Water. ° F.	Alt. Ft.	Av. Vel. Wind. Mi.	Sunshine. %
Norfolk, Va.	50	78	102	+ 2	59	29.923	212.00	10		54
Oklahoma	31.7	70	104	−17	59	28.722	209.94	1214		67
Omaha, Neb.	30.8	70	106	−32	50	28.819	210.11	1037	8	60
Oswego, N. Y.	37.0	76	100	−20	46	29.604	211.44	292		
Philadelphia, Pa.	40.6	71	103	− 6	54	29.880	211.92	42	10	57
Pittsburgh, Pa.	36.8	72	103	−20	53	29.100	210.59	738	6.1	44
Portland, Me.	42.8	75.5	97	−17	46	29.818	211.82	45	5	58
Portland, Ore.	45.6	75	102	− 2	53	29.907	211.97	20	7	41
Rochester, N. Y.	34.5	73.5	99	−12	47	29.413	211.12	498	11	47
San Diego, Cal.	9.4	77.5	101	+32	61	29.874	211.91	40	5.8	68
St. Louis, Mo.	37.1	69.5	107	−22	56	29.416	211.12	466	11	60
St. Paul, Minn.	28.6	71	104	−41	45	29.090	210.57	758	7	54
Salt Lake City, Utah.	15.8	53	102	−20	52	25.622	204.30	4293	5	62
San Antonio, Texas.	28.4	67	106	+ 4	69	29.270	210.88	660		
San Francisco, Cal.	22.5	80	100	+29	56	29.882	211.92	28	9	63
Santa Fé, N. M.	14.2	45.5	97	−13	49	23.274	199.60	6980	6.9	76
Seattle, Wash.	37.0	76	96	+ 3	52	29.940	212.03			41
Spokane, Wash.	18.3	64	104	−30	48	27.963	208.59	1881	4	52
Springfield, Ill	37.4	71.5	107	−22	52	29.336	210.99	607	..	
Syracuse, N. Y.	34.3	73	100	−20	47.2	29.375	211.05	500	11.6	45
Tacoma, Wash.	..	..	...	..	50	29.938	211.85	..		
Toledo, O.	30.8	74	99	−16	50	29.333	210.99	597	9	52
Vicksburg, Miss.	53.8	73	101	− 1	65	29.760	211.72	226	6	61
Washington, D. C.	43.1	73	104	−15	55	29.893	311.95	75	5	57
Wichita, Kan	30.4	68	107	−22	56	28.589	209.70	1308		
Wilmington, N. C.	51.5	79	103	+ 5	63	....	....	37	7	62
Yuma, Ariz.	3.1	42	120	+22	72	29.727	211.66	141		

Averages from Weather Bureau records covering the period of 30 years from 1873 to 1903.

subject during the summer to extreme temperatures of 100° F. Likewise, with the exception of the extreme south-east and south-west, frost may penetrate. To find a site for manufacturing purposes anywhere in the United States that sometime during the year would not be cold and at other times uncomfortably warm, would be problematical.

WIND.

For a few of the cities I have been able to obtain wind velocities. These interest us because air in motion is usually cooler than air at rest. Due to rapid air currents, Boston, New York City, Buffalo

and Chicago are more pleasant to live and work in during the hot season than they would be with a normal air velocity. Bausch and Lomb of Rochester, in answer to my circular letter, complain of the very cold Genesee River wind on the west side of the main building. In common with the experience at other plants in exposed places equal heating becomes almost an impossibility. Any city is more favorable for manufacturing if a mild, cool breeze blows during the summer. The hot dry winds of the west are to be avoided, as they have a very depressing constitutional effect.

Sunshine.

The sunshine Table II, Col. 10 is fairly complete. All of the United States receives more than 50% average sunshine. The south-west 70% and the North Pacific states 40%.

Chart No. 2, copied from weather bureau map No. 20, shows how the principal cities of the United States are located respecting mean annual temperature. These lines are interesting in connection with our later discussion.

In Chart No. 1, I have taken liberties with a government map by drawing a quadrilateral that comprises the greater percentage of all manufacturing in the United States. This includes Portland and Baltimore on the east and Milwaukee and St. Louis on the west. Within this area, the miscellaneous elaboration of raw materials thrives, almost without limit. Why it is possible to draw two lines that include a narrow manufacturing belt in the North temperate zone is not at once evident. The powerful civilized peoples of early history were found in tropical and semi-tropical countries of Europe, Asia, Africa, North and South America. The Hindoos, Greeks, Romans, Hebrews, Egyptians, Aztecs and Peruvians attained a high state of civilization in warm and hot climates. The frigid weather of England, Scotland and Germany during the northern winter drove the Roman legions shivering homeward. Nature planned for a migratory human race, leaving the tropics in the spring only to return in the autumn. The advance of the frost line toward the equator dictates a change in habitation and any effort to remain north of this must be accompanied by unusual provisions. In spite of these natural limitations, manufacturers thrive in a temperate climate and, from the investment and nature of the occupation are compelled to remain in

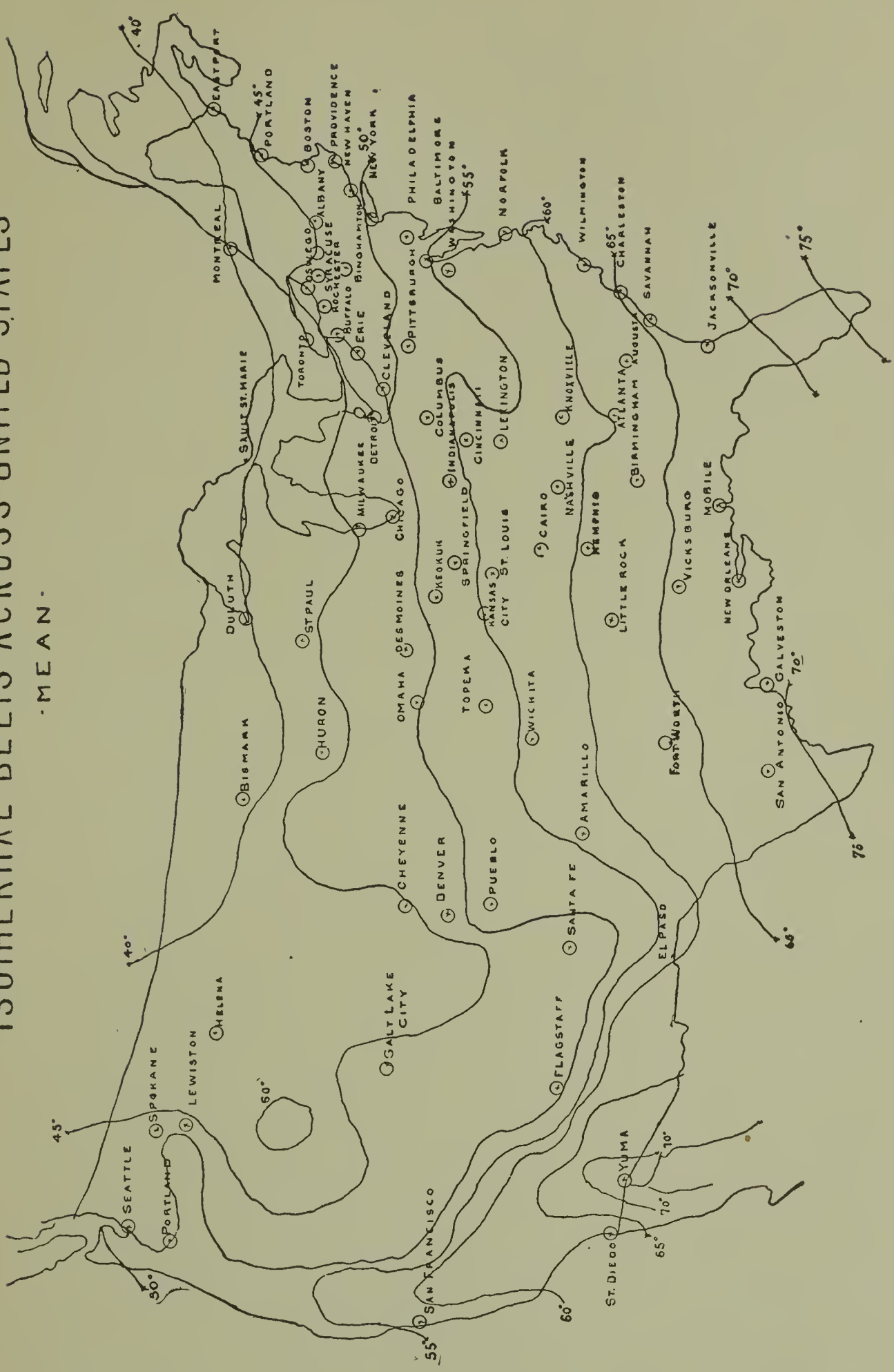

ISOTHERMAL BELTS ACROSS UNITED STATES
·MEAN·
40°
45°
50°
55°
60°
65°
70°
75°
80°
MONTREAL
EASTPORT
PORTLAND
BOSTON
ALBANY
PROVIDENCE
NEW HAVEN
NEW YORK
OSWEGO
SYRACUSE
ROCHESTER
BUFFALO
ERIE
BINGHAMTON
PHILADELPHIA
BALTIMORE
WASHINGTON
NORFOLK
WILMINGTON
CHARLESTON
SAVANNAH
JACKSONVILLE
SAULT ST. MARIE
TORONTO
CLEVELAND
PITTSBURGH
COLUMBUS
INDIANAPOLIS
CINCINNATI
LEXINGTON
KNOXVILLE
ATLANTA
BIRMINGHAM
AUGUSTA
MOBILE
VICKSBURG
NEW ORLEANS
GALVESTON
SAN ANTONIO
FORT WORTH
DULUTH
ST PAUL
MILWAUKEE
DETROIT
CHICAGO
HURON
BISMARCK
OMAHA
DES MOINES
KEOKUK
SPRINGFIELD
TOPEKA
KANSAS CITY
ST. LOUIS
WICHITA
CAIRO
NASHVILLE
MEMPHIS
LITTLE ROCK
AMARILLO
SEATTLE
SPOKANE
LEWISTON
PORTLAND
HELENA
SALT LAKE CITY
CHEYENNE
DENVER
PUEBLO
SANTA FE
FLAGSTAFF
EL PASO
YUMA
SAN FRANCISCO
ST. DIEGO

CHART 2.

an unnatural environment a portion of the year. To do this, many sacrifices of capital have to be made. The importance of constant and uniform employment of labor and machines during the working day and year in all industrial plants is well understood and practiced by successful managers. The best superintendents of my acquaintance are ready to make many personal sacrifices that "production" may remain normal in spite of men, machines and the elements. The rigors of a northern winter often tax the ingenuity to the utmost. Frozen pipes, anchor ice, snow and cold rooms keep many a superintendent anxious from December until warm weather.

Before discussing the location of a plant, let us divide manufacturing industries into groups respecting the source of raw materials or their equivalent.

1. Those that are compelled to locate near the source of the raw material, such as lumber mills, flour mills, cotton gins, sugar cane mills, beet sugar factories, cement plants, quarries, cheese, butter and condensed milk factories, canning factories and meat packing houses.

2. Those that must locate at or near a natural source of power, such as plants producing electricity from water power.

3. Plants, the location of which is fixed by fuel supply; coke production, steel and iron furnaces.

4. Good market locations; foundries and machine shops, clothing manufacturing, all articles of household use, water and gas plants.

5. Plants, the location of which is determined by climate; cotton and silk carding and spinning, and linen weaving.

6. Industries, the sites of which should be chosen; as agricultural implements, automobiles, cotton and woolen manufacturing, boots and shoes, brass products, smelting and refining, carriage and wagon factories, chemical manufacturing, knit goods, leather and paint plants.

For the latter: No. 6, fuel and raw materials may be shipped hundreds of miles if the related conditions are favorable. A careful analysis of the factors of location should be made for this class.

The shipment of fuel, stock and finished products places the manufacturer at the mercy of the transportation companies. Our northern climate absolutely prevents the continuous use of inland

water ways for from three to eight months annually. To avail himself of cheap water freight rates, the manufacturer must move a year's supply of fuel or stock during the short navigation season. What is gained in a low rate is often more than outbalanced by interest charges on materials which must be protected by insurance in a warehouse. The railroad more nearly approximates a perfect system of transportation. This, however, is also subject to the vagaries of climate thruout our main manufacturing belt, shown in Chart 2.

All classes of manufacturing in central and northern New York suffer annually from lack of fuel supply during January and February. Stalling of raw stock and frequent passenger and freight demoralization north of a line connecting Portsmouth, N. H., Pittsfield, Mass., Troy, N. Y., passing thru Utica, Rochester, Buffalo, Detroit and Milwaukee, is not uncommon. In this region, shipments are lost in snow drifts and passenger service is sometimes suspended.

Our northern manufacturers are put to great loss and inconvenience because of disadvantageous location due to climatic conditions during January, February and March.

The March 29th, 1913, issue of the *Engineering Record* states that "low temperature increases practically every item of operating expense" of a railroad. In the middle Atlantic states, the train load is decreased from 15 to 30% in the winter. This additional operating cost must be paid by the manufacturer whose commodities are transported.

All power plants suffer from low temperatures. Water ways accumulate anchor ice that is difficult to handle and frozen water mains cause hours of delay and require many dollars to repair. Water, steam and soil pipes are necessary in every industry. The further north the location, the greater the annoyance and expense incident to frost. My own work has been greatly hindered in this way and it has seemed at times impossible to start water flowing thru frosted pipes, altho easy to keep it running afterward. In one instance, my men fought a temperature of $-10°$ F. for more than a week with two complete tie-ups before water could be made to flow for some distance continuously thru one and one-half inch pipes.

Being no respecter of persons or things, gas is not exempt from the ravages of cold weather. In a northern city, a main of con-

siderable size was carried over a bridge thru a boxed conduit packed with horse dung. During a spell of extremely cold weather, I found the candle power of the gas lowered from 14 to 9 at this crossing.

Heat.

I do not know of an instance where the extreme heat of our northern summer has any marked effect upon the mechanical equipment of railroads or the power plants of mills. Labor, however, responds quickly to climatic changes. During July and August, the cities in our manufacturing belt are subject to about three weeks of what is termed "close" "hot" weather. Many plants give employes an enforced vacation and take advantage of this time for the annual "clean up" and the necessary repairs. When the temperature reaches 80° F. in central New York with extreme humidity, the average workman is incapable of much effort, either physical or mental. The mercury sometimes steadily climbs by night and day until it reaches the 100° mark. Factory discipline is demoralized, all are nervous, irritable, tired and cross. Production suffers accordingly, unless there are many automatic machines. Men in foundries, before furnaces and ovens and in closed areas, caring for special apparatus accustom themselves to great heat, and dress accordingly. The heaviest work of the year in the canning industry has to be carried on night and day during the hottest weather. The employes are usually totally unaccustomed either to high temperature or long hours and their work suffers accordingly.

Mill locations are sometimes low, compared with the surrounding country. Extended areas of this character are often covered by fog from four until eight o'clock A. M. during periods of high humidity and cool nights. Summer colds become epidemic from damp rooms and air.

Some mill owners have taken steps to relieve extreme weather conditions by suitable apparatus. More need to do so. Many modern school buildings are now well equipped with humidifying and air purification plants that could to good advantage be used by manufacturers.

Severe snow or rain storms are shown on the time clock records by tardiness and absence. Such may occur when orders are

abundant and help is scarce or when a special order must be finished by a certain time. It is usual to deduct the time so lost from the pay envelope of the employe. Severe and inclement weather over a period of several days sometimes demoralizes a northern mill where women are employed. Uniformly bad weather compels operatives to live but a short distance from the plant, which is usually a disadvantage from a home standpoint.

Considering extremes of heat and cold, white labor seems best qualified by temperament to work in the isothermal belt bounded by the 45th and 50th° F. lines. See Chart 2. Intensive miscellaneous manufacturing cannot thrive in the areas south of this because white help cannot work the year around in closed rooms at the high temperatures found south of Baltimore. See Chart No. 1. The indifference of labor in the so-called "black belt" of the extreme south is one of the greatest handicaps to the manufacturer who builds a plant where extremely cheap labor abounds. Besides picking cotton in the open, the colored man has little value in the skilled labor market.

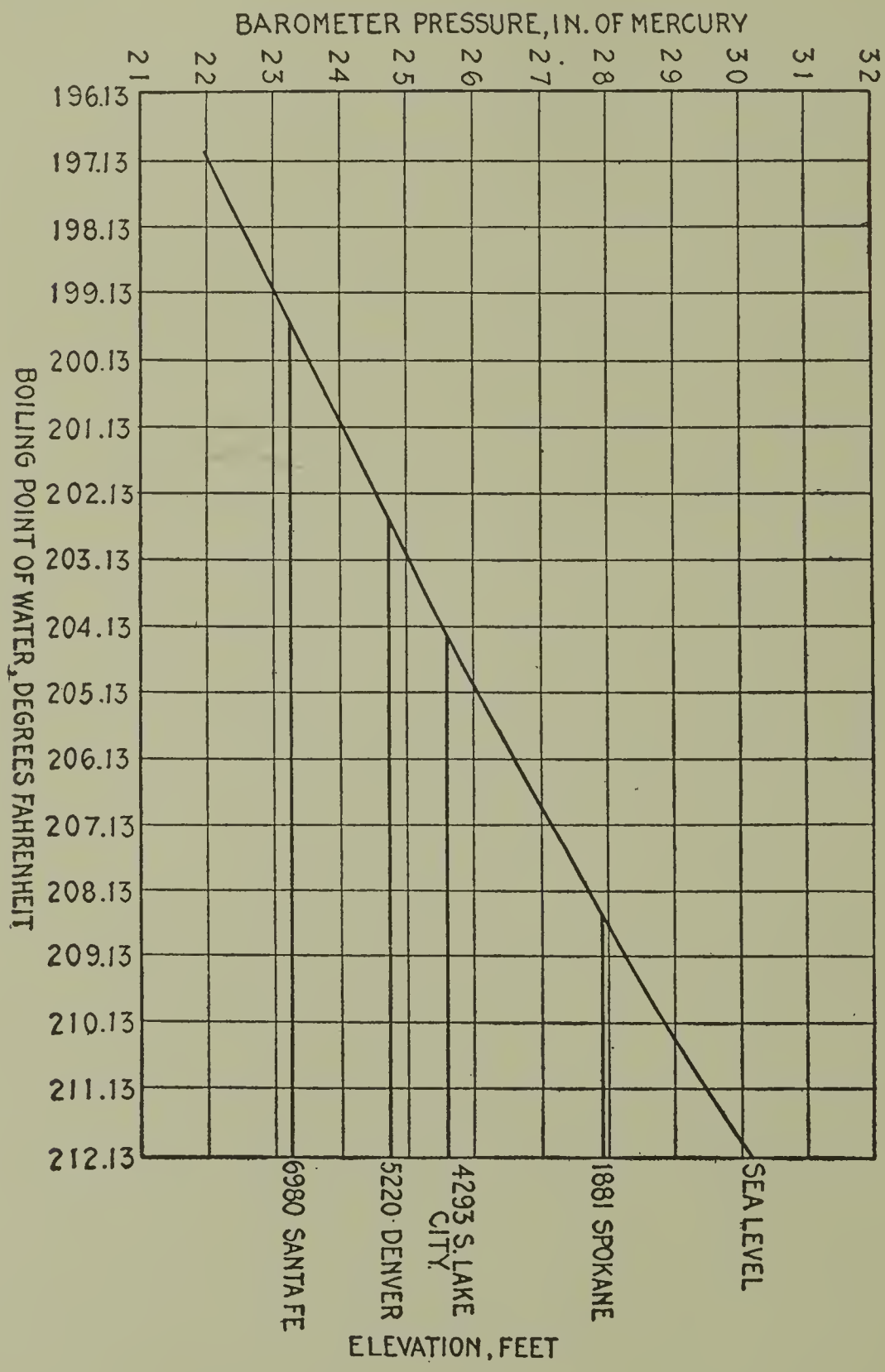
I see no reason why intensive manufacturing cannot be carried on in Washington state and Oregon, as soon as labor and market conditions warrant such activities. The humidity is sufficiently high in Portland and Seattle for textile mills. White employees can be utilized, for the 45-50° F. isothermals of the east also include these localities. California must depend very largely in this particular upon Asiatic races now employed in the fields,—Hindoos, Chinamen, Japanese and Malays.

Parts of Texas, Arkansas, Colorado and Utah are sufficiently elevated to attract white labor in mills during the greater portion of the year.

Atlanta has such an elevation as to place it in a temperature class considerably further north,—about 3° F. In the east, all locations are greatly favored by a medium altitude. There are many mining camps in the United States, however, the elevation of which is sufficiently great to seriously affect the workmen. Those with weak hearts cannot be employed and the extreme dryness of the air cracks the lips, face and hands. The body tires easily and a heavy day's work is absolutely out of the question. At some altitudes, women cannot be employed, due to their sex.

It may seem unnecessary to mention the effect of sunshine upon labor. This is, however, an important consideration as the

mind is more free and the body alert during a bright day than on a dark or cloudy one. There is twice as much sunshine in south-western cities as in Cincinnati. I know many workmen who com-



plain because certain industrial cities are in a cloud belt. One superintendent says dull weather keeps him morose and cross and has a bad effect on his workmen. After all, the familiar allusion to the weather when one meets an acquaintance is very ex-

pressive of the kind and amount of work that can be done that day, wherever temperament enters the question.

From an opposite extreme, we may mention a foreman who declares that his men lose much time during a sunshiny day by raising and lowering shades. This he wishes to rectify.

Machinery is ordinarily free from atmospheric changes. However, warm weather loosens belts and lowers the percentage of product. I have timed a machine, turning out 8000 pieces per hour, and have found a difference of 600 pieces, due to irregular belt slipping.

We now come to the most important feature of our subject to the manufacturing chemist. I refer to apparatus and process work. My attention was first called to this in testing out a milk drying machine at an altitude of 1100 feet. Neither thermometer nor barometer satisfied the conditions imposed. We finally settled the difficulty by reducing directions to changed altitude and succeeded fairly well.

In the manufacture of gelatine capsules, small cone-shaped forms are dipped into liquid gelatine. These pass out of the fluid, are elevated and dried by a current of warm air. This must be dry, and should be kept uniformly so by a conditioning process. One of the most hygroscopic substances with which I am acquainted is glucose. This has many uses and will absorb enough water to spoil other bodies with which it is mixed if the air is humid; equally difficult to manage is dry malt. Flour must be barreled and starch must be boxed in a dry room. Glycerine is very hygroscopic. Calcium chloride and caustic soda should be handled in very cold or dry air. Chloride of gold cannot be bottled on very moist days. Dry laundry chemical mixtures should be mixed and bottled or boxed in a dry atmosphere to prevent caking. Mr. Tripp of Indianapolis calls attention to the importance of conditioned air in the manufacture of gelatine, effervescent capsules, hypodermic tablets, chocolate and lard. I have experienced the greatest difficulty in getting information from manufacturers who have made a study of this subject. This is to be expected. Two engineers who have answered my inquiries remark that competition and good business compel silence. My own experience in drying has proved the importance of uniform and dry air.

On the other hand, linen, cotton, jute and hemp must be spun and woven in very moist air. Many thousands of dollars have

been lost by erecting a textile plant in a locality where the air is too dry. Fall River, Providence, Lawrence and Lowell owe their being to a moist (75% humidity) air, with fairly uniform temperature, favorable to cotton spinning. Cotton manufacture has failed in dry air localities; it flourishes in moist air. The city of Denver was chosen for cotton mills and the experiment tried but partially failed because of lack of moisture. Small steel metal parts must be made in a reasonably dry climate. The enameled leather business is dependent upon sunshine. I have known a plant practically closed, waiting for a sunshiny day, that the leather might be banked in the open air, facing the sun.

In this connection, no development has been of more interest than the Gayley dry air blast furnace treatment. Some time since I visited a large plant that has suffered great loss from air slaking of lime stored in bags. I suggested that lime has been kept in cold storage to good advantage; in this instance concrete, air-tight cisterns have been built and are used successfully.

Dye houses are very susceptible to climatic changes and I have seen few only that have clear air. This is accomplished by an overhead blast of warm air. In many instances, I have walked or been guided thru fog and mist.

Artificial lumber drying is an absolute necessity. The kilns with which I am familiar depend upon steam coils under the lumber and vertical cold water coils above and at the side. The moisture leaves the lumber, enters the air and is condensed on the coils, running into the sewer.

When a superintendent tells me that climate has no effect on his output, I know he has not made a study of his conditions. I have never yet been in a mill where climate does not exact a penalty due to the carelessness or ignorance of the management. The finished product is no exception to the exactions of temperature. Food products and aqueous solutions must not freeze; japanned articles must not be chilled; metal parts must not be packed in damp material or stand in damp places in transit.

Northern mill owners and workmen are subject to a climate tax in the way of fuel, which may be estimated. In central New York, an industry employing 200 men and women burns three tons of coal for heating purposes exclusively, during each 24 hours of the winter months. This coal costs $3.00 per ton. Exhaust steam is not available as it is used for other purposes. The 200

employees represent about 60 families that burn on the average six tons of coal each annually for purely heating purposes. This costs $6.00 per ton; a total of about $4000 for fuel due to a northern location in what may be considered a small industrial center in a country village!

To attempt to locate an industry where destructive wind storms are unknown would be impossible. The losses to all classes of business from this cause average about $1,000,000 per year, divided among house and office owners, farmers and manufacturers. The loss in 1896 amounted to $14,000,000 and severe storms of this character have often recurred in the Mississippi valley. Whether earthquakes are atmospheric phenomena or not is debatable. The capitalist is not apt to risk his money where the ground is unstable. The Charleston and San Francisco earthquakes are the only destructive ones that I, personally, can remember having occurred in the United States during the past 40 years altho I understand the ground trembles slightly many times per year.

The annual floods of the Ohio and Mississippi valleys cause hundreds of thousands of dollars loss. Of this manufacturers pay their share.

The Allegheny mountains system contains many narrow valleys with steep sides that have been appropriated by manufacturers. Great loss occurs thru the freshet season.

Syracuse users of Niagara electric current have occasionally been greatly inconvenienced by loss of power and light when feed wires are struck by lightning somewhere along the line. I understand that this difficulty is not uncommon where electric power is utilized and conveyed great distances at high voltage.

Summary.

I have had two objects in view in the preparation and presentation of this paper. The first of these has been to unite certain data that have been collected by the weather bureau for various purposes and to apply these facts to the solution of the problems of plant location.

Having plotted an area that satisfies climatic conditions most favorably, this becomes one unit of a system of maps that may be

superimposed, each of these representing the best location for an industry and covering the following:

Accessibility of raw materials
Market
Transportation
Labor
Power
Water
Supplies
Climate
Hygienic conditions
Taxes
Insurance
Banking facilities
Heating and lighting

A practical manufacturing site can, for a given industry, be determined in this way in advance of the purchase of property or the erection of buildings.

The second object of this paper is to show that owners, superintendents and operators of manufacturing plants have seldom considered the various favorable and unfavorable effects of climatic change on the business in their charge, that many improvements may be made even in poor locations by heating, cooling, drying, filtering or adding moisture to the air of their rooms where operators work or where delicate processes are carried on.

In connection with the preparation of this paper, I am indebted to Mr. Morgan R. Sanford of the Syracuse Weather Bureau office; to those firms that answered my return letter and to Miss L. B. Foster, of Denver, Colo.

RECENT DEVELOPMENTS IN COMMERCIAL EXPLOSIVES

By E. A. LeSUEUR

Read at the New York Meeting, December 10, 1913.

The last few years have seen a great development in the use of safer explosives than were previously commercially available or even believed to be possible. It is my purpose to take a brief general view of the trend of development, to deal with some particularity with an explosive of rather unique character with which I have had much experience, and incidentally to outline certain advantages and disadvantages of the new types.

The most striking feature amongst the changes occurring in the field is the almost omnipresence of nitrate of ammonia. Although a salt of a hypothetical metal it breaks down into a gaseous mixture containing a surplus of free oxygen and no solid residue whatever and, insofar, is therefore peculiarly suited to employment in explosives. Unfortunately it is very hygroscopic and of deplorably low specific gravity so that but a comparatively small weight can be packed into a given cavity. On the other hand its adaptability, within the above limitations, is remarkably wide and we find it associated with almost every ingredient known to explosives manufacture, and especially with nitro-glycerine. So wide is the present market for this material for use in explosives that practically the entire output of the gigantic Norwegian Atmospheric Nitrate Works is now delivered in the form of nitrate of ammonia, and further developments in the cheap manufacture of this important compound are to be looked for in the very near future.

Perchlorates, and especially perchlorate of ammonia, have numerous advocates among the inventors, but so far do not appear to have entered the market to any very great extent. Perchlorate of ammonia is obviously, from its chemical formula (NH_4ClO_4) well adapted to act as an explosive itself and at the same time provide two and one-half atoms of excess oxygen to combine with additional material. Aside from any other considera-

tions, it possesses the serious defect of liberating considerable hydrochloric acid or a mixture of the same with chlorine. The use of certain powdered metals or of saltpeter in the mixture serves very largely to eliminate both of the above gases.

A most profound impression has been made in the explosives trade of late years by the nitro derivatives of toluol, and especially by the various commercial mixtures of di- and tri-nitro-toluol now on the market. The cheddites (practically mixtures of nitro-toluols with chlorate of soda and a vegetable oil, preferably castor oil) have achieved considerable well earned popularity, and the flood of current patent applications for explosives containing tri-nitro-toluol reminds one of nothing so much as of that which occurred some ten years ago for acetylene generators. Bearing in mind that tri-nitro-toluol possesses certain of the properties, so far as explosive effects go, of nitro-glycerine itself ; that it withstands water and is not affected by cold, and that it can be handled with absolute safety until blended with other materials that may increase its sensitiveness, it is not difficult to understand the enthusiasm with which it has been received by amateurs as well as by others in the explosives field. Aside from any admixture with other materials it forms, in the refined condition, an explosive of quite ideal properties for use in shells, torpedoes, mines, and the like. In spite of its fierce and terrific disruptive energy, and of an enormous speed of detonation, it is a safer material to handle, transport and store than, for instance, ordinary calcium carbide. And, notwithstanding its inert behavior, it can be depended on absolutely to explode completely when exposed, in a suitable physical condition, to detonation from an adequate primer. Several European governments are now making extensive use of this intensely interesting compound. Owing to the fact that its constitution ($C_7H_5N_3O_6$) presents too little oxygen completely to combine with the carbon contents even to the monoxide form the result of explosion is the formation of a cloud of carbon particles which will presumably have its advantages in warfare both through marking the position of a shell at the instant of explosion and by obscuring the enemy's vision.

The liquid nitro-toluols are also finding an important use in connection with nitro-glycerine. They greatly lower the freezing point of the latter, contribute their quota to the explosive effect, and render the resulting explosives much safer than before.

In addition to the above compounds and many others (including the nitro-naphthalenes, benzenes and xylols) the old stand-by, chlorate of potash, holds its own as a prime constituent of modern disruptive powders. It may be worth while to glance for a moment at the extraordinary thermo-chemistry of the chlorates and perchlorates, the same having a vital bearing on the matters of energy developed, sensitiveness and stability of certain explosive mixtures containing them.

Chlorate of potash disengages heat energy to the extent of 93,800 calories per kilogram molecule on formation from its elements, but potassium chloride disengages 105,700 calories, or 11,900 *more* than the chlorate. The addition of three atoms of oxygen to the chloride is accompanied by the absorption of energy to this latter extent, the formation reaction being endothermic. Perchlorate contains one-third as much oxygen again as chlorate, but, instead of the addition being accompanied by a further absorption of heat, there is actually a disengagement of energy, accompanying the entry of this lone atom, of far more (19,900 calories altogether) than the entire amount absorbed when the first three atoms were added. Chlorate stands ready to fall to pieces on scan provocation and, in doing so, give up not only three atoms of active oxygen to any combustible in the neighborhood, but 11,900 calories per kilo molecule as well. Perchlorate, on the other hand, in spite of its higher degree of oxygenation, requires more energy to drag it to pieces than does the chloride itself, and, in consequence, forms a less sensitive and less energetic constituent for an explosive than the less oxygenated chlorate.

In the light of the above, and especially in view of the fact that the besetting trouble with most modern chlorate explosives is lack rather than excess of sensitiveness, it will be seen that plain chlorate presents certain large advantages over perchlorate for many explosives. This will help to explain the fact that, although modern electrochemical methods enable the ready production of perchlorates, the latter have not, as stated above, so far become serious competitors in the field of commercial explosives.

To illustrate the remarkable extent to which the desensitising of at least one chlorate explosive has been carried without destroying its practical usefulness I will now cite the case of an explosive developed by me some seven years ago which has been in somewhat widespread practical use since that time.

In manufacturing this powder 5 parts of paraffine wax are melted and 4 of ground sulphur and 22 of nitrate of soda stirred into it; the mixture is allowed to cool and is then grained. The resulting material is called "mineral base." In spite of containing an oxidising agent and combustibles it is completely inexplosive technically. It is finished to explosive by dusting 8 parts (to the above 31 of base) of powdered chlorate of potash over the grains. The final material possesses a number of interesting features. Due to an extremely low speed of detonation it develops its power in a way peculiarly available for the requirements of many large applications such as heavy rock work, clearing land of stumps, and the like; and, owing to the said low speed of detonation, its high effectiveness for these purposes, even compared with explosives possessing decidedly greater energy content, is quite surprising. Its insensitiveness is such that it withstands the impact of a steel tipped service rifle bullet, fired from the regular service rifle with a standard charge behind it, without response of any kind; although, due to its property of going out after being set fire to when the flame causing ignition is removed, it is possible that incipient ignition occurs during the passage of the bullet. If packed hard it is impossible to explode it by any means whatever. On the other hand, loaded loose, it is an absolutely sure fire with a No. 6 detonator even when unconfined, and, for work in earth, as in removing stumps, it is necessary to bear in mind that confinment may be negligible. When well confined in large shots in solid rock, and especially if detonated with a stick of dynamite, it will withstand any reasonable amount of packing and still give a sure fire. From its composition it will be obvious that it is non-freezing, and, indeed, owing to the paraffine wax incorporated in it becoming harder with increasing cold, it loses its porosity through being pressed into holes less readily cold than otherwise. With regard to stability, it withstands the International Stability Test (75°C. for 48 hours) with indifference, whether with moisture added or not, and some millioms of pounds have been used during the past seven years, and in some cases excesses over requirements have been stored by contractors in badly constructed magazines occasionally for years, and there has never been any sign of heating or decomposition, incipient or otherwise.

The very low chlorate content and the fact that all the other materials are used in their crude commercial condition, together

with the extremely simple process of manufacture, render the cost of this powder exceptionally low. It is known under the name of R. R. Virite. A blast containing 600 fifty pound cases was fired on the Canadian National Transcontinental Railway work on the Quebec-New Brunswick border, near Notre Dame du Lac, some years ago, and the two largest blasts at Prince Rupert, the Pacific Coast terminal of the Grand Trunk Pacific, 3500 miles from Notre Dame du Lac, were also shot with it, said shots containing respectively 1010 and 1000 fifty lb. cases of the explosive. Aside from the technical importance of these blasts the spectacular effect is quite indescribable. To give an idea I may say that in the one of these shots that I witnessed the mass of broken rock that had mounted in the air about three seconds after explosion occurred, and which looked like nothing so much as a vast and spreading black tree, contained, to state it in units that will make it sound as impressive as possible, about 175,000,000 lbs. Reference to the efficiency of virite in agricultural work is contained in bulletin No. 134 entitled "Land Clearing," issued by the University of Minnesota from the pen of Prof. A. J. McGuire, Sup't of the North Central Experiment Station.

With reference to the property which this explosive, in common with very many others, has of being more difficult to explode as its porosity diminishes, I wish to point out a certain important corollary which exists in a case where the insensitiveness when closely packed reaches the point it does in a case such as the one under discussion. If compressed forcibly to a specific gravity of about 1.45 it has been found impossible to explode by any amount of detonation, no matter what the degree of confinement. This in spite of the fact that a certain small amount of local combustion occurs where the material is in direct contact with the detonator. The superficially paradoxical situation confronts us that the only condition in which the matrial can be exploded by hammering between hard surfaces is one in which it becomes insensitive to detonation from another explosive. By this is meant that, in order to cause explosion of the powder by hammering, it has to be packed to a maximum density before the pinching between hard surfaces necessary to cause explosion occurs. Of course what happens when the material is hammered on an anvil is that any excess over what can be pinched down to the thickness of thin paper between hammer and anvil is forced aside and only the trifling amount of powder

actually so pinched goes off, and it has hitherto been found impossible by any degree of practicable impact to communicate explosion from the quantity so pinched to the rest of the mass of powder. The importance of this peculiarity in securing freedom from accidents in any case other than where the powder is exposed to detonation from another explosive will be obvious.

If we consider what is the fundamental difference between the blow of a hammer and that of a detonator we see at once why a mass of the explosive which refuses to transmit detonation however powerful (within the enormous upper limit experimented with) when in a dense (non-porous) condition,—why such material may be readily exploded when in a porous condition by a detonator although a blow from a hammer can only have a local effect. The point is that, in the former case, the blow is struck so quickly that the explosive is hammered between the products of explosion of the detonator and, if I may so express it, its own inertia, without having time for its porosity to be interfered with. The passage of a bullet exposes it to the same kind of a blow against its own inertia, but the swiftest bullet is so far inferior in speed to the velocity of the products of explosion of a detonator that it falls short, in the case of a powder of the class under discussion, of producing an explosion. There is also, of course, the essentially important feature, in the case of explosion by a detonator, of exposure to vastly greater heat than from the friction of a bullet or impact of a hammer.

The well compressed material behaves, as previously stated, in a completely inert fashion to attempts to detonate it, but mere crumbling restores it to the explosible condition. It would seem as though a technical division on the lines of classification according to safety might well be adopted to embrace explosives that require outside detonation from another explosive in order to set them off.

No general survey of the field of explosives development should omit reference to liquid oxygen as a constituent of explosives. Modern methods exist for producing this element in a state of high technical purity in the liquid form at a cost extremely low compared with its cost in the combined form in any of the chemicals employed in the explosives trade so that completely smokeless and fumeless mixtures equal to 75% dynamite can be made at a cost of about 2c. per lb. As regards safety, explosives containing liquid oxygen stand in a class

by themselves in one particular, i. e., in the fact that, should a shot be missed for any reason, the charge presently becomes inexplosive through volatilisation. Of course this is merely the merit which accompanies the greatest defect of these explosives: They must be used within a few minutes of being compounded. Nevertheless this is by no means the absolutely prohibitive feature that might be expected, owing to two considerations, one the numerous gigantic individual blasts that are necessary on certain heavy construction works (the time required for the charge to evaporate being comparatively long in such cases) and the other the fact that the addition of the liquid oxygen to the combustible portion of the charge may be made the last thing before firing. I am rather firmly of the opinion that in the heaviest construction works of the future, especially where the so called "coyote" shooting can be employed, liquid oxygen will play an important part.

This paper is intended to deal with accomplished facts in explosives development and there is no occasion at present to do more than refer briefly to the hopes of the nitro-glycerine manufacturers that in synthetically prepared glycol may be found the solution of their bondage to the fluctuation of the corn and cotton seed crops. The production of glycerine depends considerably on the abundance or otherwise of pork and of cotton seed oil and the former depends largely on the corn supply. The stearine candle industry, another feeder to the high explosives maker, is not in a healthy condition, and altogether the situation of the dynamite manufacturers is not so completely free from anxiety in the matter of their glycerine supply as they might wish.

NOTE ON CERTAIN UNPUBLISHED WORK ON ELECTROLYSIS USING SUPPORTED MERCURY KATHODE.

E. A. LeSUEUR

Read at the New York Meeting, December 10, 1913.

I commenced work towards a commercial solution of the wet electrolysis of common salt in 1888 and my first efforts were devoted to the mercury kathode, the results obtained in that year being what I propose to describe. At that time all the rugged appurtenances of a successful commercial apparatus were yet to be developed in order to lift any process for the purpose out of the laboratory. It therefore came about that, in considering the immense distance to be traveled in order to surround the invention of the supported mercury kathode with the necessary concomitant equipment, and in the light of certain simplifications possible when using the diaphragm process, I gradually worked over to devoting myself exclusively to the development of the latter. It may not be out of place to say that it was this development which became, less than five years later, the first commercial contributor of caustic soda and chlorine to the world's markets (see paper by Prof. C. L. Parsons in Am. C. S. J., Nov. '98) and which, if I may be allowed to say so, embodied those essential features of diaphragm success (such as excess liquid pressure on the anode side) which have since been used by everyone working in this field.

Referring to the 1888 work; it seemed to me obvious that, with a view to eliminating sodium from the solution, the worst possible place to put it was on top of a layer of mercury exposed to contact with said solution. The point is that, although sodium dissolves in mercury, the initially formed amalgam is of very low specific gravity compared with mercury itself and naturally tends to stay on top of the latter save as a sluggish tendency to diffusion operates otherwise. It seemed to me that the obvious alternative was to use the under side of the mercury as the kathode, the upper side being completely exterior to the electrolyser as such; with the idea that the sodium, as fast as it was delivered to said

under side, would float up to the upper side and be thereby removed from relation with the electrolyser and its contents.

This I proceeded to do, using a horizontal square frame of paraffined pine wood, a supporting sheet of a special cotton fabric carried by the under side of said frame, and additional support supplied to the fabric by a paraffined wood grating. Mercury was placed on the fabric to a depth just sufficient completely to cover it and a current supplied from a primary battery of three large two fluid bichromate cells between a carbon anode and the under side of the mercury, saturated salt brine being the electrolyte.

The first run made with this cell will always be a painful memory. I started it on a certain Sunday morning in July and then went off for a walk to a point 7 miles distant. Returning in the evening I looked at the cell and saw to my disgust that the mercury was covered with liquid and that there were grains of some white material resting on the mercury in said liquid. I jumped to the conclusion that the layer of mercury had become discontinuous and that hydrostatic pressure had forced brine up over it and that partial evaporation had precipitated crystals of salt. Just to see what it tasted like I put my finger in the liquid and touched it with my tongue and then removed it with speed because the liquid was an oily 50 to 60% solution of c. p. caustic soda and the white grains were undissolved particles of same. Of course what had happened was that sodium had entered the mercury from the under side and oxidised and hydrated, in moist air, from the upper side, and a portion had deliquesced in additional moisture abstracted from the air. I have always felt convinced that this general principle would work up to the best possible type of mercury kathode electrolyser, but I also took the view, at least in the 90's, that unless some great commercial advantage accrued from being able to supply c. p. caustic, the best diaphragm process could on the whole do better than any process using a mercury kathode. However, seeing that mercury cells are in considerable use I am unable to understand why the apparently obvious principle above described has not been employed. In the light of the principle so clearly grasped in connection with the above quarter-century-old work, it is curious to note, in Wilderman's address before the World's Congress last fall, the repeated remarks on the disadvantages all processes previous to his have labored under of putting the light sodium in on the top layer of mercury and leaving it there.

A SELF-DUMPING FILTER PRESS.

By E. J. SWEETLAND

Read at the New York Meeting, December 10, 1913.

That there is great room for improvement in the methods of filtration commonly employed cannot be doubted. The plate and frame filter press ordinarily used comprises anywhere from forty to one hundred filter chambers each of which must be cleaned individually by hand every time the filter is filled.

It was to eliminate the excessive amount of hand labor in cleaning filter presses that the filter under discussion was primarily designed, but as the construction was developed many incidental advantages of importance developed with it, as will be pointed out further on.

The single advantage in plate and frame filter presses that has kept them in favor is the fact that their peculiar construction affords a very large filter area in a comparatively small space. Filtration cannot be forced beyond a certain reasonable limit, when this limit is reached, it is necessary to increase filter area to increased capacity. To endeavor to increase capacity by increasing pressure instead of filter area is futile, for excessive pressure merely presses the cake to a compact, almost impervious layer and the object is defeated at once.

With this in view, the modern filter must not depart from a construction that permits of ample filter surface. Other things being equal, the capacity, and consequently the value, of a filter is proportional to the filter area.

The sluicing type of filter press is one example of a filter press construction that eliminates hand labor in cleaning. In this type the cake is disintegrated by a stream of water forced into each chamber. The cake thus liquefied flows to the waste reservoir, or dump. The usefulness of this method is limited for obvious reasons, principal of which is the need of recovering the cake as dry as possible in most processes.

The uses of filter presses are so varied that great flexibility is required. One process will demand a filter capable of handling a thick sludge containing twenty or thirty per cent solids, forming cakes probably four inches in thickness, which have to be thoroughly washed; the next problem may consist of clarifying a viscous fluid containing but traces of solids, so finely divided as to make a thick cake an impossibility. One problem calls for recovery only of the solids, the filtrate being of no value, while another rejects the solids as refuse after recovering the liquid content; still another requires recovery of both liquid and solid. Some plants make certain products at certain seasons and must use the same filter press for an entirely different product at other seasons. To be a commercial success it would seem that the modern filter press should lend itself to these various requirements and the construction made adjustable as far as possible.

As will be seen from the following description the filter under discussion is a radical departure from the plate and frame filter press and is even more simple in construction.

Construction.

This filter has become known as the "Clam shell" type due to the shell being in two parts hinged together to open and close somewhat after the manner of the clam shell bucket used on steam shovels.

The filter body comprises two semi-cylindrical members hinged together, one member being provided with an inserted gasket which seals the joint between the two to form a water-tight cylinder when closed. Fig. 1 shows an end and side elevation of the filter in closed position.

A plurality of openings is provided along the top to receive the stem or outlet nipple of the filter leaves. These outlets are spaced quite close together so that the leaves may be closely spaced if desired, as is the case when thin cakes are to be formed; but the leaf spacing may be increased to any degree by taking out part of the leaves and stopping off the intermediate outlets.

Variable spacing is quite essential, for it is not always possible to ascertain in advance exactly what spacing will be best suited to the material; and further, there is always the possibility of the process being modified to change the filtering properties of the material and make a change in leaf spacing desirable.

The filter leaves are usually made of wire screen, well crimped to provide ample drainage. The screen is bound at the edges to stiffen the construction and protect the cloth. An outlet nipple with a side opening furnishes an exit for the filtrate and means of holding the leaf in the filter body. The filter cloth covers the entire metal construction of the leaf except the outlet nipple and is held on either with metal clips or by being stitched around the edges.

The leaves are held in place in the filter by a cap nut which engages the top of the nipple and draws the shoulder of the leaf

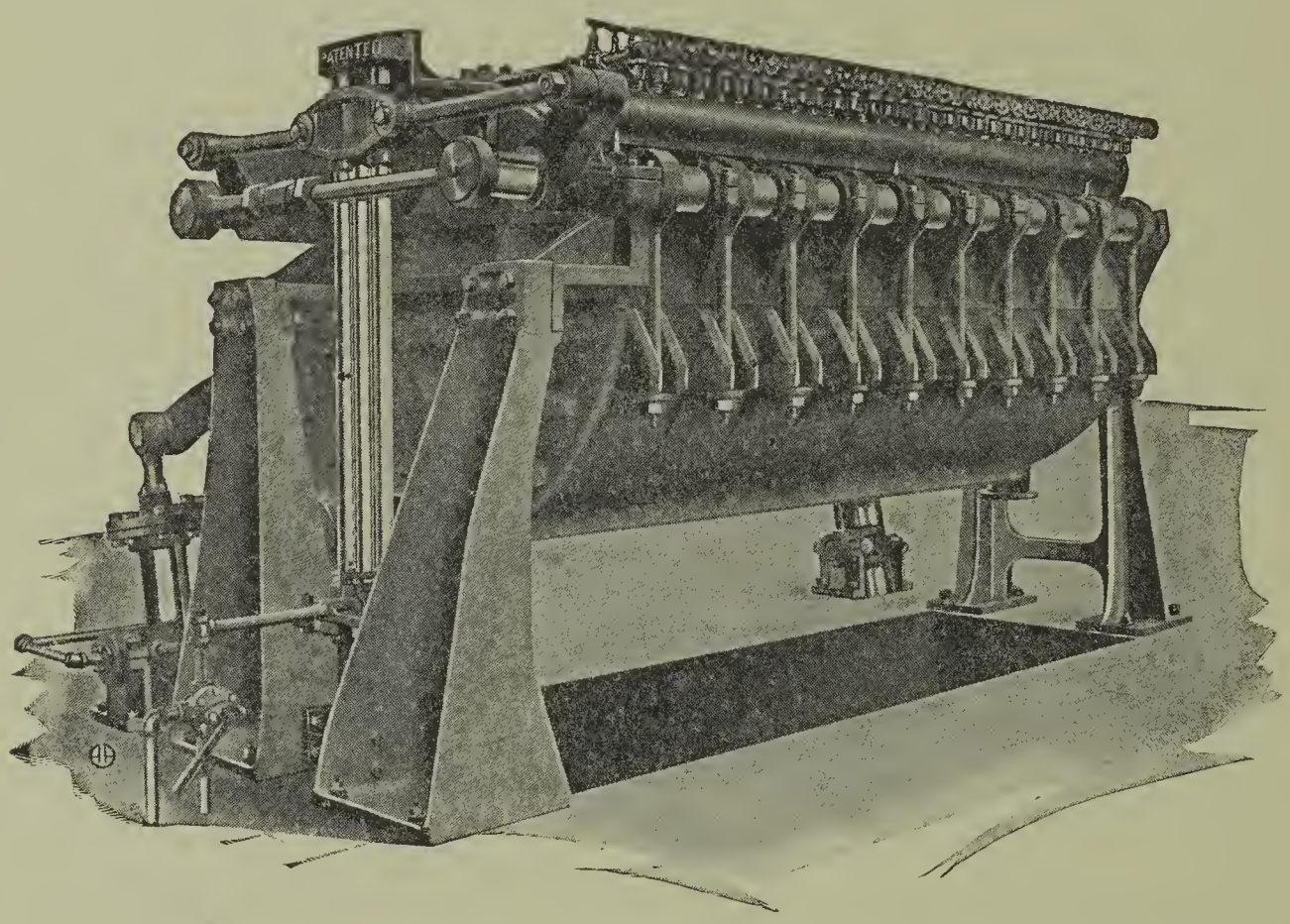


FIG. 1.—Closed Filter.

tightly against the rubber washer which fits in a recess inside the filter body. The side outlet of the nipple aligns with the filtrate delivery fittings on the outside of the press.

Fig. 2, which is a cross section of the filter body, clearly shows how the filter leaves are held in place by the nipple at the top. Each leaf has separate outlet fittings comprising shutoff cock, glass delivery tube, etc. These fittings allow the operative to see the filtrate from each individual leaf as it flows through the glass, and any leaf that may become injured or require renewal of cloth is indicated at once by a turbid filtrate in the glass. In this event the shutoff cock governing the defective leaf is closed until

the filter is opened and the leaf replaced. To remove a leaf the cap nut only has to be removed—the outlet fittings are not disturbed.

In the earlier designs of this filter the two halves of the shell were held in closed position by hand operated swing bolts. These were fairly quick and convenient to operate, but still left room for improvement. It was desired, if possible, to modify the construction to an extent that would reduce the time to unlock and open the filter from a few minutes to a few seconds. This was accomplished by a very simple change in the construction. The hinges, which formerly took no strain while the filter was in locked position were increased in strength and number and made to take the

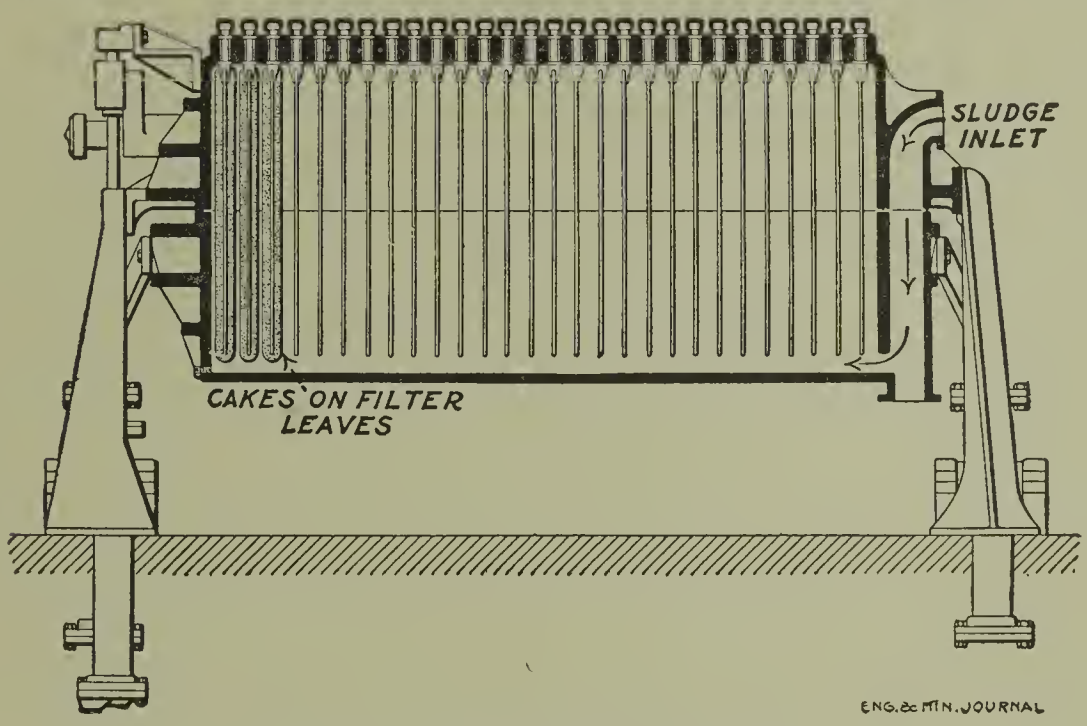


FIG. 2.—Cross Section of Filter.

strain formerly taken by the swing bolts on the back of the filter body. To eliminate any possibility of breakage, the hinges are made of steel, which can be fully depended upon for strength. What seemed the great problem in working out this improvement was the need of accurate hinge adjustment to take up wear in the gasket. This problem like many mechanical problems proved to be simpler than was anticipated, for it was solved by simply making the hinge pins into one continuous shaft reaching from end to end of the press, and turning the bearing which received all of the hinges on the upper member eccentric to the normal axis of the shaft. This construction not only affords adjustment, but makes adjustment of all hinges simultaneous by simply turning the hinge shaft slightly when adjustment is necessary to draw the upper

and lower halves of the shell closer together as the gasket gradually flattens out from continued use. The shaft is held from turning by set screws, which are loosened when adjustment is made.

An eccentric shaft with swing bolts rests in babbitted bearings along the front of the upper half. Each bolt has an adjusting nut and lock nut for initial adjustment and for taking up wear. The swing bolts are tightened or loosened simultaneously, due to the eccentricity of the shaft, when the latter is turned through an

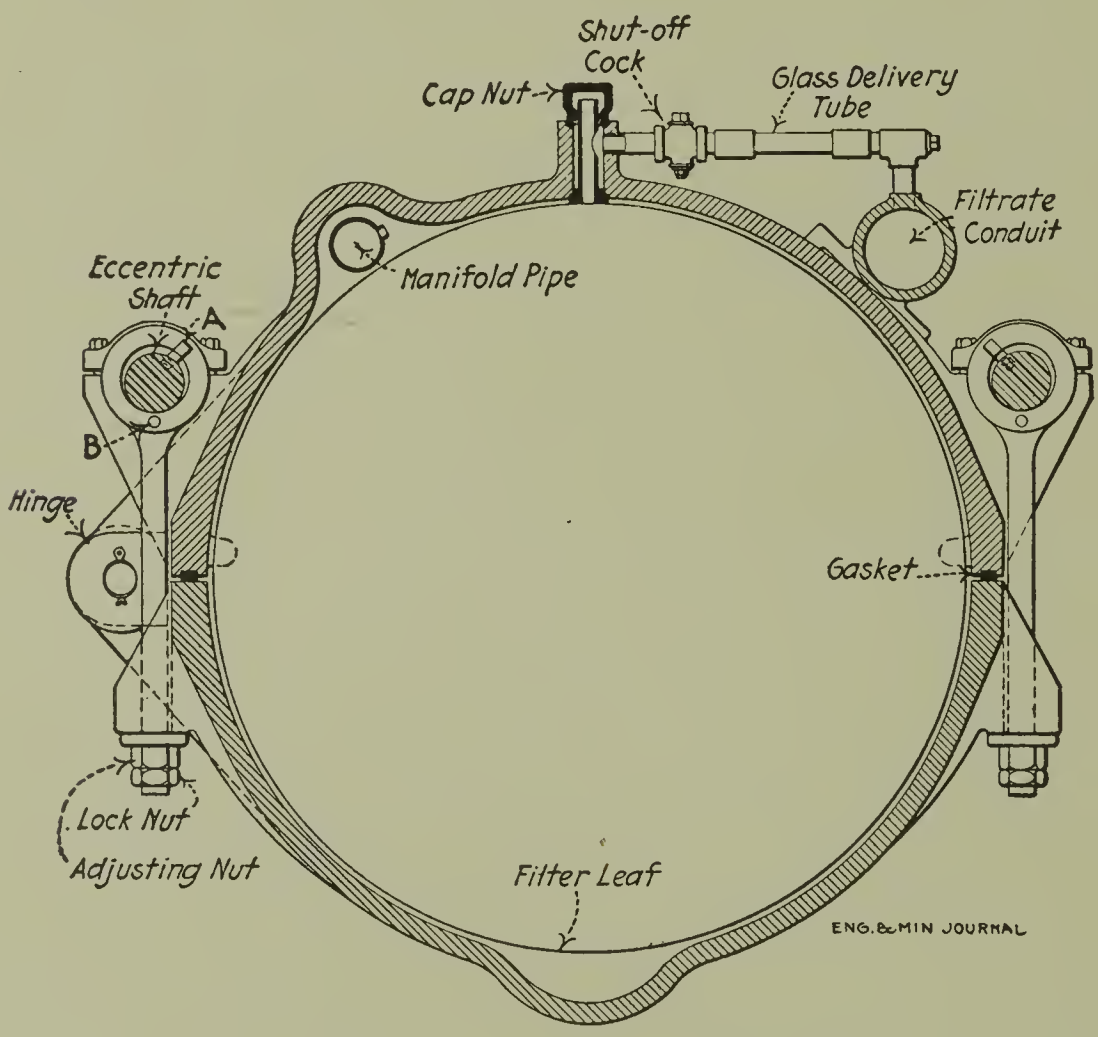


FIG. 3.—Sectional View of Filter.

arc of 180° and means is provided of swinging the bolts clear of the lugs on the lower half just at the point when they have loosened sufficiently to disengage themselves.

This arrangement makes it possible to open or close a filter press of moderate size in a few seconds. The lower half of the shell is poised with counterweights to facilitate opening and closing. A sectional view, showing hinges, eccentric shaft, etc., is shown in Fig. 3.

In large machines an eccentric shaft is used on both front and back, and a hydraulic cylinder operates the two simultaneously

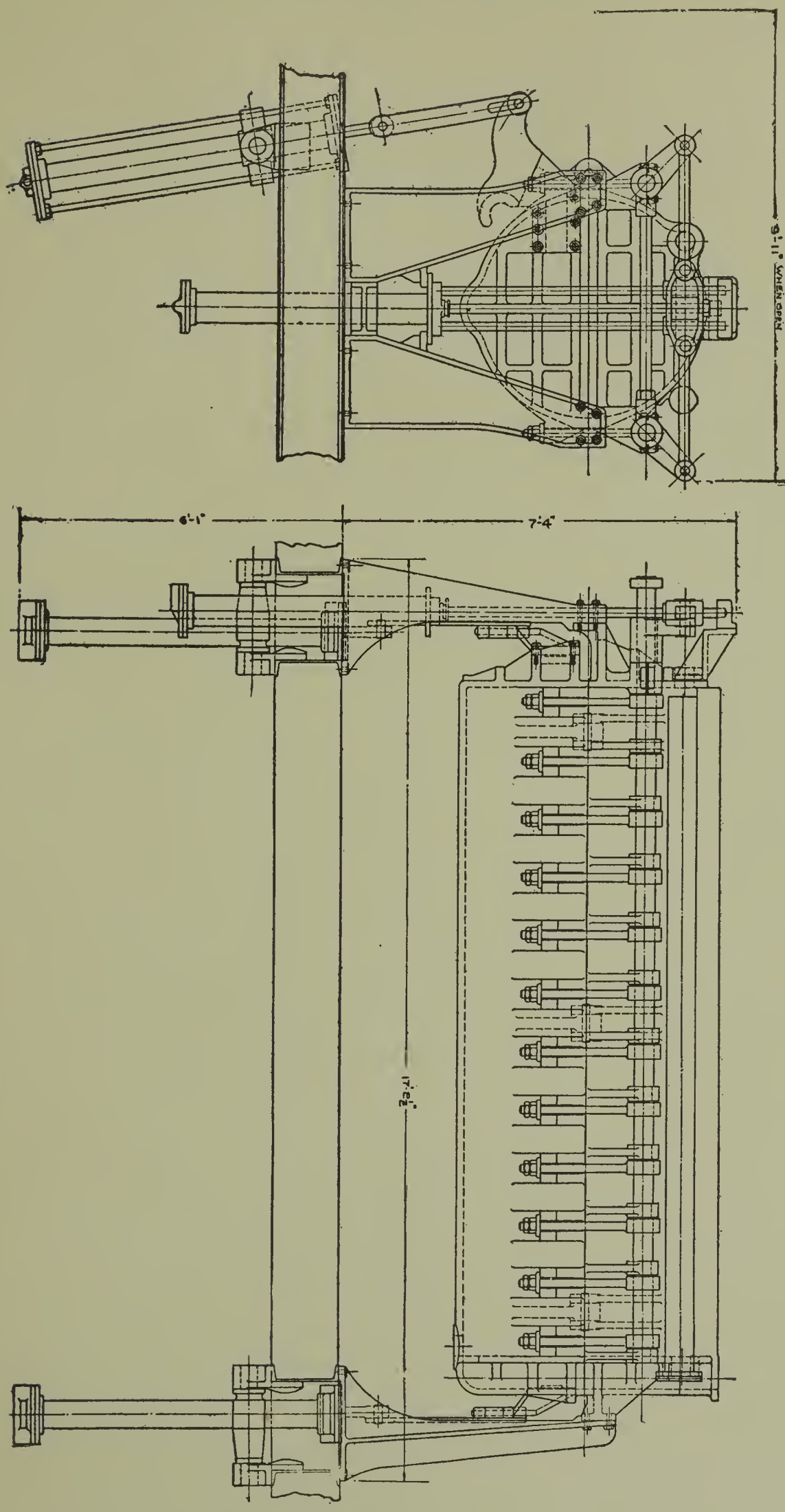


FIG. 4.—End Elevation and Side Elevation of Filter Press in Closed Position.

by means of a cross head and connecting rods. The lower member in this case is swung open and shut by a hydraulic cylinder at either end which is so arranged that the shell is opened so wide as to invert it and thus clean itself of any cake that might have fallen before it was fully opened.

Operation.

In operating the filter the liquid to be filtered is forced into the filter body under pressure, expelling the air and entirely submerg-

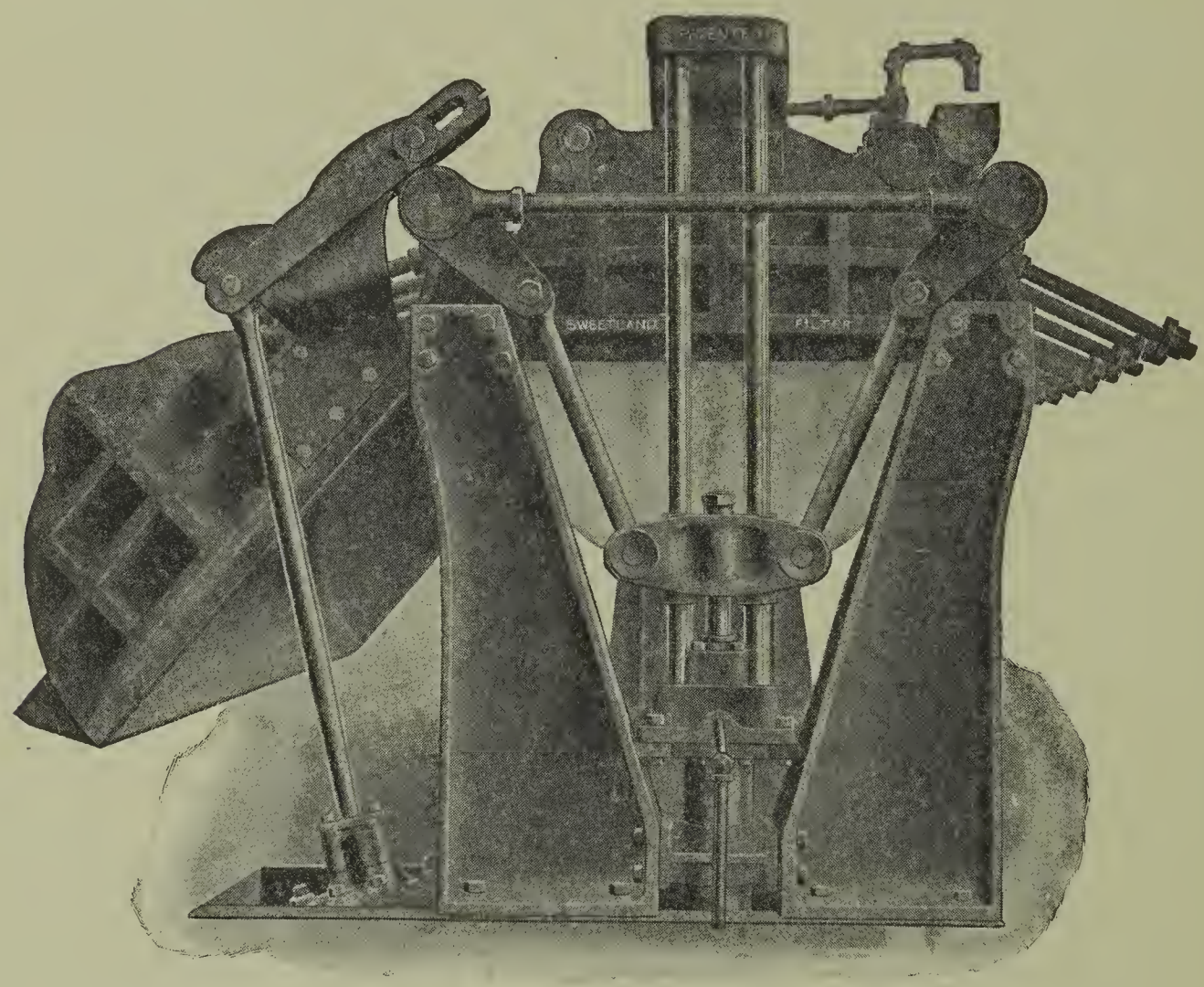


Fig. 5.—Filter Open.

ing the filter leaves. The liquid filters through the cloth and deposits the suspended solids on the outside of the leaves, forming the "cakes." Filtration continues until the cakes on adjacent leaves are separated only by a narrow space which may vary in width from 1/8 inch upward. When the cakes are formed to the proper thickness the wash water valve is opened and sludge valve closed simultaneously. The wash water enters the space between the cakes forcing the small quantity of unfiltered sludge to deposit

its solid component upon the cake surface. The space between adjacent cakes is now occupied by water, which being under pressure, percolates through the cakes, driving the strong liquor ahead and effectively displacing it until the cakes are washed to the desired degree, which is indicated by frequent tests of the effluent.

I feel justified in enlarging somewhat upon the subject of washing the cakes, for therein lies a great difference between this and other leaf filters. It should be noted that there are no chambers or containers to be packed solidly full of cake. The spaces between the leaves are not packed solidly full, but a cake is deposited on the surface of each leaf and these cakes are allowed to build up until only a narrow space remains between them, and in this space lies the secret of successful automatic discharging of the filter, and efficient washing. The cakes have been formed under equal conditions, the sludge being evenly distributed and the pressure equal throughout the filter chamber; therefore the cakes must be of even thickness and density and must wash evenly. That this actually occurs has often been demonstrated by testing samples of the washed cake from various parts of the press.

All filters of the leaf type wash by "direct contact" methods; that is, the wash water is in direct contact with the cake; but the methods of washing that have heretofore been practised with leaf filters whether vacuum or pressure are indeed anything but direct.

The usual method of forming and washing the cakes on filter leaves is as follows, assuming that the cake has to be washed first with weak liquor and then with water:

1st. Fill filter tank.
2nd. Deposit cake on leaves.
3rd. Withdraw excess solution.
4th. Fill filter tank with weak solution.
5th. Wash cakes with weak solution.
6th. Withdraw excess weak solution.
7th. Fill filter tank with water.
8th. Wash with water.
9th. Withdraw excess water.
10th. Discharge cakes from leaves.

Here are ten distinct operations, which are still further complicated by the fact that the cakes will not cling to the leaves unassisted, but must be held on with either compressed air or vacuum

during the time each quantity of excess is withdrawn. I do not dispute that the cakes can be washed well by this method, but raise the point that it is an extremely round-about method of accomplishing a simple object. Most of the power consumed is not devoted to filtration but to transferring solutions, much of the time is not devoted to filtering but to waiting for transfers to be made, and the operative is kept busy manipulating valves.

The delay in filtering necessitated by the many transfers materially cuts down the duty of the filter, and the process becomes a complicated one, requiring many tanks and much accessory apparatus to take care of excess solutions.

Nor is this all. The transfers of excess solutions referred to introduce other complications. The cakes must be supported upon the leaves at all times by pressure. Air pressure (whether produced by suction or otherwise) must be used during the transfers. If too much pressure is used, the cake will be cracked (due to the shrinkage of partial drying) and the wash water will "short circuit," that is, pass through the channels formed by cracking. If too little pressure is used, all or part of the cakes may fall from the leaves, which would preclude the possibility of efficient washing. Lastly, if the cakes are of a fine slimy character, the partial drying during the transfer packs the particles of slime, and makes it less pervious than ever to the passage of wash water.

The origin of the many complications cited above is traced directly to void or "dead" space in the filter tank or chamber which contains the filter leaves. If there were no dead space, there would be no excess solutions, and consequently none of the complications which attend them.

The "clam-shell" construction of filter body has no void spaces. It contains nothing but the filter leaves and manifold pipe. When the filter leaves are loaded with cake, the entire filter chamber is full except the feed channel for distribution along the bottom, and the narrow space between the cakes for the entrance of wash water. There is therefore no excess solution to handle. Filtration is continuous from the time cake forming is commenced until washing is finished, and the process of filtering and washing is reduced to the simplest possible terms.

When washing is finished, the cakes are partially dried with compressed air, the lower half of the filter body is swung open and the cakes are dumped into a car or conveyor underneath. To assist

the cakes to dislodge from the leaves, the current is reversed by turning steam or compressed air inside of the leaves, which not only causes the cakes to drop off, but benefits the cloth by keeping the pores open.

For the benefit of those who insist that better washing can be obtained by draining the filter body before introducing wash solutions or water, I would point out that the filter construction here described offers every facility for carrying out this method, if desired; but after installing many of them, large and small and under widely varying conditions, and seeing trials made both ways, I strongly advocate the direct method without withdrawing solutions.

If the material is very slow-filtering and the space between the cakes wide, then it is better to introduce the wash water through the manifold pipe and let the water entering the top fill the chamber by downward displacement, forcing the excess solution out of the drain valve at the bottom. The water, being lighter than the sludge, does not mix with it, but floats on top during displacement. In this case filtration is continuous, pressure is maintained in the chamber, no time is lost, and the cakes are constantly submerged.

It is so frequently asked why the body of this filter was designed cylindrical instead of square that I shall take this opportunity to point out the reason. Obviously the principle could be carried out in a filter body of square or rectangular section. The reasons for cylindrical construction are:

1. The cylindrical construction affords great strength whereas any shape with straight sides would require so much reinforcement to give it the necessary strength as to make it cumbersome and awkward.

2. The leaves are exposed to view by simply swinging the body open.

3. A circular leaf is conveniently supported from one point and is very strong and light.

4. If the chamber were square, the leaves would be inaccessible, or else would have to be lifted out with the cover to discharge and this would involve mechanical difficulties.

The circular form of leaf does not involve as much waste in filter cloth as might be imagined. There is to be sure a slight waste of cloth cut from the corners, but most of this has an important use in reinforcing the cloth at the edges of the leaf. On the other

hand, a large percentage of the cloth used in plate and frame presses is not used for filtering, but to form a joint between the frames. If we figure it out in any case, we find that the percentage of cloth purchased that is utilized as filter medium, is about the same in either case. In fact the cost of cloth per unit of work done is much less in the case of the leaf construction, because the capacity per square foot is greater, and the cloth is not injured by being squeezed between the frames.

As to filtering mixtures containing coarse particles, these offer difficulty in any type of filter, due to the coarse particles settling to the bottom, making the bottom of the cakes more porous than the top and resulting in uneven washing. The remedy for the trouble is to keep the contents of the filter chamber in a state of agitation. To accomplish this, the feed pump is provided large enough to supply the necessary pressure for filtration with additional capacity enough to permit a restricted overflow to run from the manifold pipe back to the supply tank during filtration.

New light is being thrown on the subject of filtration with almost every new installation, and problems are being successfully solved that appeared at the start to be impossible of solution. To cite an instance: A sample of a heavy viscous liquid was submitted for test. It contained a gummy residue that blocked the filter cloth from the start, and the rate of flow of filtrate per square foot of cloth was but a few cubic centimeters per hour, and the cloth became so coated as to defy cleaning by any practical method. As the solution only was required, and the residue was worthless, there seemed to be no objection to adding some inert granular substance to the liquid as an aid to filtration. A series of experiments was undertaken, adding various "filter aids" to the fluid, and the outcome of this work was that an average rate of filtration of three gallons per square foot of cloth per hour was obtained and the gummy residual matter was sufficiently broken up to permit the filter cloth to be readily cleaned by reversal of current. Upon completion of the tests, a filter was installed in the plant and has fully demonstrated the practicability of the method on a working scale. It was found that any one of several substances could be used as an aid to filtration, among which are fine sand, fuller's earth, kieselguhr, sulphate or carbonate of lime, sawdust, wood pulp, etc.

It is not argued that such methods are applicable to all cases,

but there are unquestionably many problems that will find solution in similar schemes, which make possible rates of filtration such as are usually obtainable only in sand filters, with the added advantage that the leaf filter offers an enormous filter area in a small space, combined with extraordinary ease of cleaning.

Another method of filtering materials containing a gummy residue that tends to choke the cloth is that of depositing a protecting layer on the cloth before commencing filtration. For instance, we may first fill the filter body with a very thin slurry of carbonate of lime and filter this mixture for a few seconds until a film of lime, say 1-32 inch in thickness has been deposited. This coats the cloth as completely and evenly as a deposit could possibly be made. The lime slurry is then drained off and filtration commenced. The coating of lime forms a complete film between the cloth and gummy residue, so the latter never even touches the cloth. When ready to clean the cloth the reversal of current is effective because the coating of lime breaks away readily.

It is frequently asked how we can tell when cakes of sufficient thickness have been formed especially when the material filters and builds up the cake rapidly. This is not as difficult as would be imagined. The usual way is to work at a given pressure, say forty pounds per square inch, and pump for a certain number of minutes, determined by practice to form the required cake. Another way is to pump a certain number of inches from the supply tank for each charge. As in all processes, the operative soon becomes expert, and can judge from the general conduct of the filter when the charge is sufficient.

The usual skepticism which attends the introduction of any new machine was encountered at first, but so many installations are now in successful use as to establish fully the usefulness of the methods described. A noteworthy point is the fact that many of the filters of the type in use are of much larger size and capacity than it is found practicable to build filter presses. Many have been built with a capacity of 133 cubic feet of cake per charge and several others ranging from 80 to 120 cubic feet per charge. One especially large one was built which dumps over 25 tons of cake per charge.

That this apparatus is now far beyond the experimental stages is demonstrated by the fact that a large beet sugar factory in California installed three large hydraulically operated machines for

the 1913 campaign. They were installed almost at the last minute before the campaign started and were at once placed in service at full capacity, and no difficulty was encountered, in spite of the fact that none of the employees who operated the machines had ever seen one before. The time required to open, clean and close one of these filters is about five minutes, which minimizes labor to such an extent that one operative can take care of several large machines, even though each machine has to be cleaned hourly.

A NEW FILTER PRESS

By Dr. ALFRED BURGER

Read at the New York Meeting, December 12, 1913.

Before describing the new filter press, I intend to give a short survey of the developments in the construction of pressure filters for filtering and washing purposes, and to point out certain lines along which improvements have been made.

If we look back a few decades it seems as though the activities in this branch of chemical engineering had come to a temporary stop with the general introduction of the chamber filter press. This machine had so many advantages that it rapidly found its way into practically every chemical factory and is still in general use to-day. It is a strongly built, reliable and practically fool-proof machine and does do the work for which it is built, though in fact badly, especially since we know that better results are obtainable.

For large scale operations, however, the chamber filter press had its limitation. Filling and washing took a long time and consequently too many machines were required for handling the slush and the cost for labor ran up very high. For this reason many plants stuck to decantation or table washing, finishing with the squeeze press. Others who were more progressive tried filtering and washing in the press but had to give it up.

Judging from the numerous attempts subsequently made to find a cheaper and more convenient way of discharging the solid matter, it appears that the separating and putting together again of the many plates and frames after each cycle plus the cost of labor involved were considered the chief disadvantages of the chamber filter press.

In trying to overcome these drawbacks it was soon found that the chamber filter press did not lend itself very well to such improvements. The only way in which the solid matter can be removed without separating the filter members is by sluicing. This method, though it has proved very successful in some cases, is but a compromise be-

tween the old way and something better that was yet to come. Besides, sluicing is only feasible if the solid matter is worthless.

Better results in this endeavour were to be expected from another kind of filter, the leaf type, which was then already in use, though in a primitive form and chiefly for clarifying purposes. It seems as though the inventors of this latter type did not have an adequate conception of the filtering problems confronting engineers in certain chemical and metallurgical fields. Nothing was done by them toward making the apparatus more useful, enclosing the leaves in a suitable shell which would permit an easy removal of the cakes.

The proposition of improving it in this direction was taken up some years later out West and undoubtedly the great opportunity there revealed has been an active stimulus to the inventors of two types of leaf pressure filters perfected in recent years.

These two are giving very satisfactory results indeed, especially that type of which a model has been exhibited at a previous meeting of the Institute. Yet, if we compare the working of such a modern leaf type filter with an ordinary chamber press, we find that the superiority of the former is due not to the mechanical discharging but to the greater washing efficiency. Thus the time required for separating the plates and frames and closing them up again at the end of each cycle seems, after all, not to be such a disadvantage as had been represented. The discharging feature, as will be demonstrated later, is in fact a secondary matter.

Besides these successful attempts to solve the problem of discharging the solid matter in a more satisfactory way than is possible in a chamber press, other lines of improvements have recently been taken up with the view of constructing a filter press in which the filtration is followed by a squeezing of the cakes mechanically and to effect filtration at a much higher pressure. But in my judgment no great advantage will be derived from this direction. Owing to the constructional difficulties to be surmounted and to complications of such a machine their use will be limited, while filtration under much higher pressure is no more effective.

Some years ago the writer became familiar with a process of which the filtration of the slush constitutes one of the most important operations and as the results obtained in the filter presses employed seemed to indicate ample room for improvements, I subsequently and incidentally gave some attention to filter press matters. It seemed to me that not so much the time and labor involved

for separating and putting together again the plates and frames but rather the low washing efficiency of the chamber press was the feature most deserving of correction.

When occasionally filtering the same material through a filter funnel in the laboratory it surprised me that the liquid ran so nicely through the cake, and in proportion much less water was needed for washing the residue free from soluble matter than the big filter press required, working with 50 lbs. pressure. This observation led me to apply the same washing principle to a chamber filter press which consists of letting the water penetrate the cake in the same direction as the solution. Fig. 1 illustrates this.

The cylindrical part of the two filter funnels facing each other resemble a section through a chamber in a filter press having an

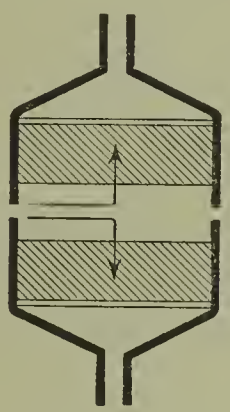


FIG. 1.

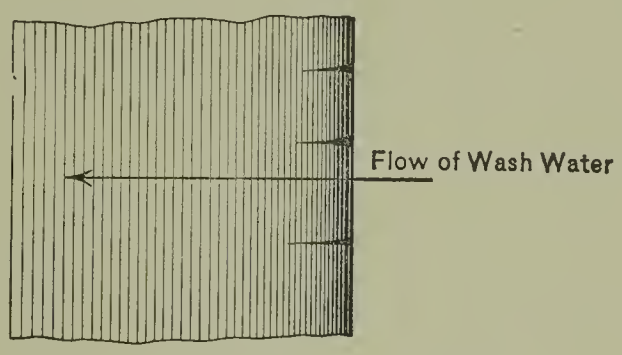


FIG. 2.—Section through Cake.

opening at the bottom and top. Two distinct cakes are formed which are washed from inside.

To what the bad washing in the ordinary chamber press is due has been discribed before, but let me add, the reversing of current is not alone responsible for the bad results obtained. Cakes which I have seen seemed to indicate that the inefficient washing, especially in case of slimy solids is due to a great extent to the uneven filtering soon after fresh blankets have been put in the press. The cakes that begin to form on the wash plate sides are, owing to the continuous good condition of these blankets, considerably denser. The very first deposit is often a relatively hard layer which on reversing the current for washing purposes cracks. Cakes occasionally examined always showed this cracking distinctly and a separate testing of the different layers revealed plainly how the water had penetrated the cakes. The hard brittle crust in one instance con-

tained about 6%, the soft central part .4% and the left layer 0.2% of soluble matter not washed out.

What I have termed a new filter press is the direct flow principle, as illustrated in Fig. 1, applied to a chamber filter press of very simple construction. The method of operation is still simpler. Fig. 3 shows a cut through the stationary head and first chamber with pipe connections. The liquid-solid enters from the bottom channel with valve "O" open. As soon as the material begins to overflow, "O" is shut. Filtration starts and is continued until sufficient

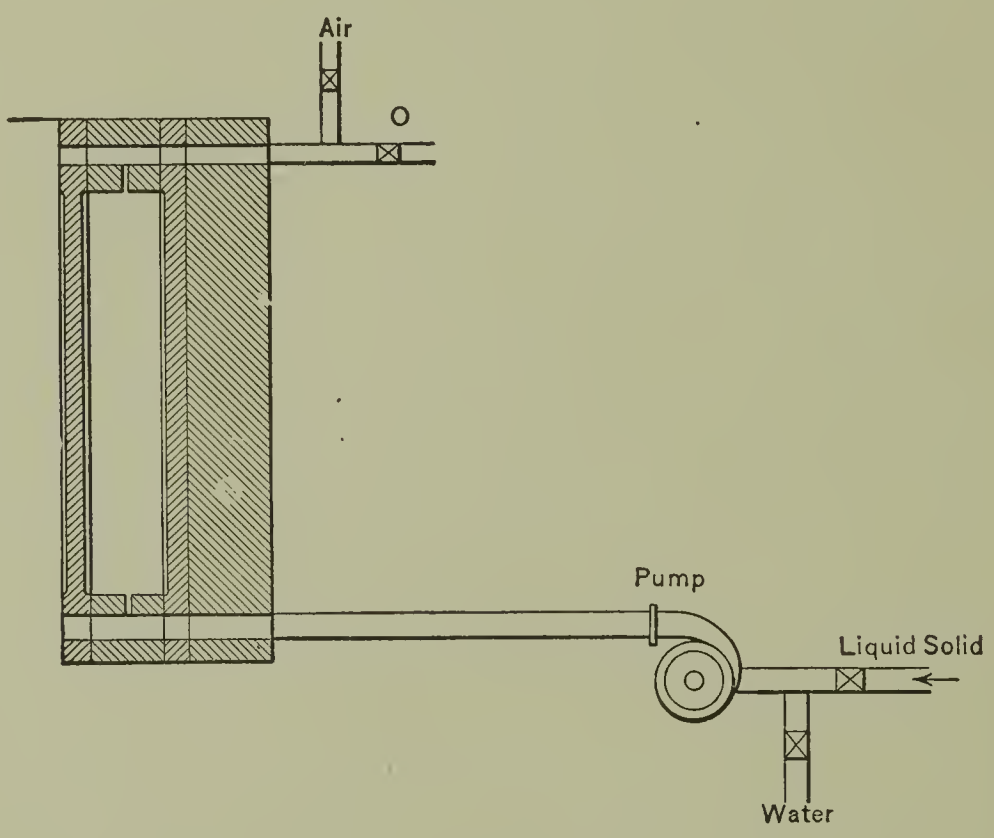


FIG. 3.

cake has formed to leave but a space in the center of ½ to ¼ inch. Water is then switched on, and after washing has been completed the excess is withdrawn by means of compressed air introduced from the top. Air is then blown through the cakes for a short while when the press is opened and the cakes discharged. Of course, the method just described is not sufficient to insure good results. Certain constructional details are absolutely essential, as otherwise trouble will arise causing complete failure. Now, rather than describing those details I prefer to give a few figures showing the work done by presses in actual operation. Thus I think it will be better appreciated what these improvements amount to.

For filtering and washing an aluminum-hydrate precipitate, it used to take six hours in the regular chamber press for washing the cakes free from the solution, while with the press of my design an hour is now required. In case of a prussian-blue, washing was reduced from twelve hours to two. A carbonate of lime residue was washed free from solution in less than one-third the time a Dehne press required and the amount of water needed for doing it was reduced to one-third.

The excellent results obtained induced me to file application for patent for this device. In looking over patent specifications as to improvements on chamber presses I was somewhat surprised to find that apparently nobody before fully realized the great advantages to be gained by this very simple mode of filtering and its general application. I want to emphasize that good results are only obtainable if filtering and washing is carried on without interruption and with steadily increasing pressure. Introduction of air or steam between filtering and washing for instance is impossible. Also a clearance must be left between the cakes of at least ¼″ to facilitate an easy and even distribution of the washing fluid.

Besides these very great advantages over the ordinary chamber press in respect to time and efficiency of washing, there are a number of others, as for instance lower operating pressure, absolutely clear filtrate, less leakage and less pressure required for keeping joints tight, which means a saving in blankets.

A plate and frame filter doing such efficient work compares very favorably with a leaf type filter equipped with the best mechanical devices for discharging the cakes. I am able to prove this with the aid of figures obtained from presses working on the same material and under identical conditions.

	Washing Efficiency	Final Moisture Content	Lbs. of Dry Solids per □ foot Filter-area per hour
I Chamber Press.....	20%	30%	0.8
II Impr. Chamber Press.....	60%	28%	3.0
III Leaf Type Press.....	54%	36%	3.5

As to the calculation of the washing efficiency of a filter press as given in the table I shall explain this more fully later on.

A glance at the collated figures reveals clearly the inferior work done by the chamber press. Its washing efficiency is only one-third of that of the two other presses, and consequently the output for unit filter area which is chiefly influenced by the washing efficiency is still less—about one-fourth. It is evident that this press drops out of consideration for processes in which large amounts of material have to be filtered and where wash water means evaporation.

A comparison of the presses II and III proves that my previous statement as to the capacity per unit filter area being principally determined by the washing efficiency is correct. The difference in the quantity of cake handled per square foot per hour in this particular case was only .5 lb. or 14%. Small indeed, and will only have an influence in favor of the leaf type press when huge quantities of material are to be put through, but then it is rather the saving in labor which will enter into consideration. On the other hand the lower moisture content of the cakes obtained in the improved chamber press is decidedly a great advantage whenever the residue is to be dried. That, together with the somewhat higher washing efficiency, will outweigh the labor item, which is in favor of the leaf type filter. Moreover, the simplicity of replacing a leaky blanket is a matter not to be overlooked.

. . . . . .

In connection with the description of the new filter press just given, I intend to add a few suggestions concerning a standard method of putting down the work done by a filter. I think there can be no question as to the usefulness of such a scheme. Filtering is one of the most important operations in many chemical and metallurgical processes and the machines are so numerous that figures computed in a like manner as to the work done by them would be most interesting and valuable. It would be of help to the engineer interested in some particular process as well as to the man who is offering a machine for effecting the separation of a liquid from solid matter.

The data given before and which I used for comparing three different types of presses defined pretty well the performances of each machine. One figure relates to the amount of water needed for washing the cakes—no doubt in many cases the most important item; the second tells the condition of the discharged cakes, and

the third data gives the amount of material handled per hour and per square foot filter area when operating continuously.

With regard to the amount of water required for practically complete extraction of soluble matter from the cakes, we often hear it expressed in gallons per ton of dry solids. While this is quite sufficient for one familiar with the material worked to do some figuring, it conveys no direct impression as to how efficient washing is carried out. For this reason I prefer to base the calculation of this item on the displacement principle, calling the washing 100% efficient if the volume of water required for practically complete extraction is equal to the volume of solution the cakes contain after they have been built up.

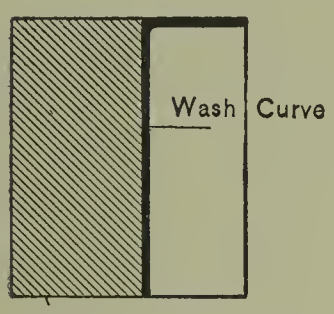


FIG. 4.
100% Efficiency.

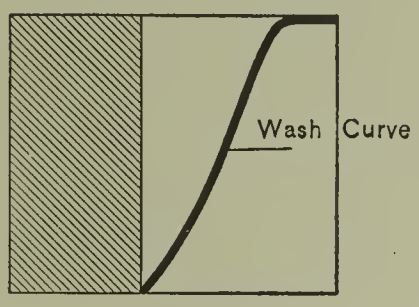


FIG. 5.
50% Efficiency.

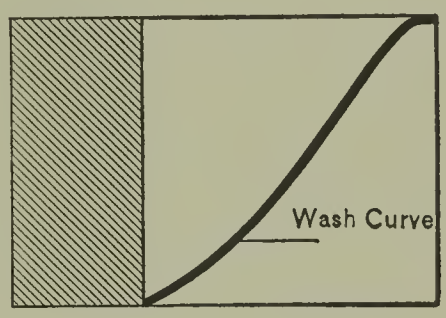


FIG. 6.
33⅓% Efficiency.

A press doing a good work should at least show a washing efficiency of 50%.

The final moisture content gives the amount of water remaining in the cakes when they are discharged. This data will assume importance in all cases where the material has to be dried.

The figure as to the amount of solids handled per square foot per hour is interesting as well as important. Interesting, inasmuch as it shows—provided the washing efficiency is about equal—how much those devices for mechanically discharging the cakes amount to; important, because it tells what size filter is required to handle a certain quantity of material in a given time.

DISCUSSION

The PRESIDENT: My attention was called to this new device by a chemical manufacturer, I believe the one to whom Dr. Burger referred, a manufacturer of aniline colors. He stated to me that with the employment of Dr. Burger's device, the time of washing was reduced from ten hours to one, and that the amount of water employed was reduced to one-third.

The principle as I see it is to have the wash water follow the same channel as the water which is removed from the material before the filter press cake is "dry" and before it "channels"; that means that a solid wall of clear water follows the water containing the impurities of the material, so that the flow through the filter is not interrupted at any time.

The PRESIDENT: Does any member desire to ask any questions of Dr. Burger?

Mr. PARKER: I would like to ask Dr. Burger where this press is made?

Dr. BURGER: My device can be attached to any chamber press and the construction of a special filter press is thereby made unnecessary.

Mr. PARKER: Is not the principle of washing the same as in the Sweetland press?

Dr. BURGER: The principle of washing is the same as in the leaf type presses, and of course, in order to obtain the greatest efficiency, it is necessary to determine for each material the economical thickness of the cakes. It is often simply a matter of putting the proper frames in.

Dr. FRERICHS: Do I understand Dr. Burger right that after the cakes have been formed there is much liquid left sustaining the cakes?

Dr. BURGER: No, sir, the space left between the two cakes is only about one-quarter of an inch. Little solution is left and this hardly mixes with the wash water but is pushed ahead through the cakes and out of the press. Once filtration is started there is no interruption in the flow of liquid until washing is completed.

The PRESIDENT: Is there any further discussion?

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Mr. CHUTE: It is rather unfortunate that the speaker is not quite ready yet to thoroughly explain this to us, because I suppose we are all more or less from Missouri, although we do not necessarily live there. But the question of filter pressing has interested me for a long time and I had made a few notes on that, but as the time is short, I would like to read them by title and have them published as part of the discussion.

There is just one little thing I would like to call attention to with regard to the Merril press. I happened to be in the Black Mills when it was first put in and I obtained from Mr. T. J. Grier lately a statement that shows that for 1912 the cost of filtering slimes was 3.834 c. per ton and for power 1.81 c., making a total cost of 5.46 c. as the cost of filtering, based on the ton of slimes filtered. In two months, nearly 100,000 tons of slimes were worked by leaching with cyanide in the Merril press, saving 26.1 c. in gold and losing 3.6 c. per ton. They have 28 presses working and they can work 70 tons per day. This shows to what an extent filtration is carried on in the mining industry and how cheaply it is done. For several years I have seen a press used with a distributor. This consisted in putting a screw through a central feed pipe, and it is especially applicable to distillery slop. By having the screw fit the central feed in the press, the sludge was much more evenly distributed in the press.

Another press which I came across one time was a centrifugal with a screw inside of the drum revolved at a slightly different speed. The drum was held so that the screw gradually pushed the solid matter through the small end of the drum, the water clinging, of course, to the outside base. This solid material was pushed into the dry end of the drum, while the water escaped to the other end.

I mention those because they are rather obscure types of presses and once in a while we come in contact with them.

The PRESIDENT: I will say that I am having a small press equipped with Dr. Burger's device and shall be very glad to show this press. If the gentlemen will give me their names and addresses, I will be very glad to let them see this plant.

OZONE: ITS MANUFACTURE AND USE

By Dr. A. VOSMAER

Read at the New York Meeting, December 12, 1913.

If I venture to give a lecture on ozone although some few years ago this same subject was treated by Dr. Linder before you, it is because my experience in this line, ranging over more than 15 years, entitles me to an individual opinion on this matter and this opinion differs in many respects from that of other people. I must here beg you not to lose sight of the fact that of all the numerous people who have been writing on the subject of ozone, there are very few who actually know something about it. Ozone is rather a queer substance. The valuable information Dr. Linder gave in his paper will not be repeated by me. I intend to give you some salient points out of my own practise, and my paper will thus not be a complete treatise on ozone but a contribution to the knowledge of this substance. For the sake of clearness, I shall divide my subject into three parts, viz.: the manufacture, the properties, and the uses of ozone.

Manufacture. This part may again be divided into two, viz.:

1. Those methods of production that have commercial value and have found actual application.

2. Those methods that have only scientific interest. I shall be very brief on this second class although they are very interesting.

If we symbolize the formation of ozone in the old way

$$3O_2 = 2O_3$$

we are making a great many mistakes. In the first place it should be written

$$3O_2 + \text{energy} = 2O_3$$

but the reaction is a very sensitive equilibrium one, it being a function of temperature and hence it should be written

$$3O_2 \rightleftarrows 2O_3$$

but even this is far from being correct according to modern views. The reaction is much more complicated than suggested by the simple equation, as we shall see presently. The ordinary way of adding energy is to apply heat. The exact amount has not been settled yet which is another proof of the fact that the reaction is not a simple one. According to Berthelot it takes about 29,800 calories while others say about 36,000 per mol. This latter figure has been corrected to 34,000 by John. When oxygen is heated in such a way that the product is taken out of the heat zone as quickly as possible, ozone will be formed. The experiment has been carried out at about 1300°C by means of a stream of oyxgen directed into a glowing Nernst pencil, but as the temperature of formation and that of decomposition lie very close together and as the rate of decomposition increases rapidly with increase of temperature, the method has no practical value at all, but it is interesting to know that the formation of ozone out of oxygen is essentially a question of adding energy or heat and not electricity.

None of the chemical methods for producing ozone will ever have a chance of success. I may remind you of those which are based upon the use of sulphuric acid and permanganate or barium peroxide or manganese peroxide. The oxygen liberated actually contains some ozone, but too little to be considered.

Another interesting but also quite useless method of producing ozone, is to have ultraviolet rays play upon oxygen. Becquerel rays will also do but such methods need not be discussed here and as there are two practical electrical ways of making ozone there is no need for a third.

These electrical methods can be divided into two, viz: the electrolytic and the discharge method. Allow me to say a few words in favor of the first method which has not received the interest which it deserves. Upon electrolyzing strongly acidulated water, that is dilute sulphuric acid (sp. gr. 1, 11) the oxygen produced may, under favorable circumstances, contain a large amount of ozone. As much as 25% has been recorded when working at low temperature and high current density. This method looks very promising and I think it probable that when taken up by some able man and developed, it will play a more important role than it has done. We may reckon one KW hour to yield over 80 grams of oxygen. If 25% of this is ozone then this means a yield of 20 grams per KW hour. (The best recorded yield is 7.5.) True, this figure

is much below the best known, viz: 80, but first of all one should not lose sight of the fact that oxygen and hydrogen are recovered as valuable by-products. Development of this method may also lead to much higher yields, and the cost price does not depend solely on the question of how much ozone is produced per KW hour of electrical energy, but depends also on many more items, such as interest and depreciation of plant.

At present, however, there is but one method and that is: passing an electric discharge of a special kind through air or oxygen. As the use of pure oxygen instead of air does not give yields that are equivalently higher (about three times), in view of the cost of oxygen, the use of air for this purpose is general for application on a commercial scale. For laboratory or experimental purposes, oxygen is to be preferred.

That brings us to the proper point now to consider more in detail the discharge of electricity through a gaseous medium. I could spend many an hour on this favorite subject of mine but I promise you to be modest and not take too much of your valuable time and patience.

Any two points showing electric potential difference, no matter how small, will give rise to the *tendency* to annul that difference. If we have a metallic conductor between them a flow of current is the result. If we have a liquid conductor said potential difference will have to have some value before any current will pass. If it be higher than the counter e. m. f. of polarization there will be a current. We have here a case of electrolytic or better to say ionic conduction, but if we imagine said points to be separated by some gas, then the question of discharge is very complicated, depending in its nature on such things as: shape and size of electrodes, nature of path, i. e. free or not, kind of current supply, viz.: d. c. or a. c. and in this case on the frequency of alternations and the wave form. It also depends on the pressure, temperature and condition of the gas and some other points of minor importance, too many to enumerate. There is a vast amount of scientific literature concerning discharges in different vacua because these phenomena bring scientists pretty near to molecules, but as far as I know there is but one single publication on the brush discharge in plenum. I have tried both lower and higher pressures than atmospheric, but ozone is made best at the ordinary pressure. I have tried down to one-half and up to two and a half atmospheres, but in all

cases this yield of ozone was lower than when working at ordinary pressure.

As to temperature, probably the lower the better. I have tried down to minus 25° C. and up to 100° C. Whether or not it pays in increase in yield of ozone to incur the expense of artificial cooling is a matter of engineering calculation and depends on the size of the plant. Refrigeration has also the additional advantage of drying the air and dry air is better than moist air for the generation of ozone.

As to the current, the d. c. not being so popular as the a. c., I mean the high tension d. c., we naturally take resource to the latter and take the frequency as given in the regular makes of alternators because although a higher frequency is a great advantage in ozone production (I have tried up to 600 periods) there comes the difficulty that the high frequency alternators have to be made specially for the purpose, which means a higher price. My own 600 period alternator gave about 20% more output than the regular 100 period. On the other hand, if we use the very high frequency currents named after Tesla, we obtain wonderfully beautiful brush discharges but very little ozone.

Next comes the question of voltage. First of all we must realize that output in ozone is related to wattage because it is a question of energy. Then we must think of the fact that down to a certain limit the output is the higher the smaller the polar distance between the discharges, but once this is fixed for a given apparatus, the voltage is fixed as well and the wattage has to be regulated by the amperage.

Dr. Linder, in accordance with Prof. Gerard said: Keep down your amperage, so as to keep down the heat, which is detrimental for ozone production, and have a high voltage. Now heat is a form of energy and the amount is not proportional to amperage but to wattage and it makes no difference whatever how the product volts $\times$ amperes is built up, energy is energy and not dependent on the magnitude of either of its factors. Gerard using a double dielectric and a pretty large air space has to have a voltage higher than the usual 10,000. That is why he speaks in favor of it, but it should not be a reason for making a scientific mistake in the argument. A somewhat troubling instance is that discharge in air does not follow Ohm's law, or it is perhaps better to turn it this way, the electrical resistance offered by a path of air is not

in a simple way related to its length and cross section. In order to keep down the heat and increase the life of the glass dielectric, there must be efficient cooling of the electrodes and glass or the amount of energy put on the apparatus must be limited. This practically means a relatively low current density, i.e., low amperage per unit of electrode surface, since we cannot alter the voltage to a large extent.

The third circumstance controlling the discharge itself, is shape and size of electrodes. Suppose you have a metallic conductor *A* connected to some source of electricity, say a step up transformer, then, according to circumstances, different things may happen. Let us assume the other terminal of said transformer to be connected to some other conductor *B* opposite the first one and have them spaced some distance apart and nothing between but air. Then unless the potential difference between those ends *A* and *B* has a certain value, no visible discharge will take place. Suppose we have some means of gradually increasing the voltage, then there will come a moment at which the electrical charge at the ends will be high enough to cause or rather to allow of discharge. It is rather difficult to have electricity come off from a metal and pass to a gas, gaseous molecules being hard to electrify, but it is only a question of magnitude of electric charge. Just before coming off, the electric charge first will show what is generally called the glow. It is a bright spot, hardly a discharge proper, but it will increase. It may under certain circumstances change to the well known corona effect or it may further change to the regular brush discharge. A further increase in potential difference will lead to a spark and this again will give opportunity for the voltaic arc.

These different kinds of discharges have to be understood well before proceeding. The glow is characterized by its quietness, no noise at all. The brush is a regular discharge, intermittent but undirectional.* It gives a hissing sound and the so-called electric wind. Its color is a pale to dark blue violet. The names, dark discharge and silent discharge for it should be abolished as being improper. It is this particular discharge that possesses that wonderful property of converting oxygen into ozone. The spark is quite another kind of discharge. It makes a loud snapping noise. Its color is a yellowish white. Its path a zigzag line—or a straight

* Experiments by Kabahjian show the brush to be an oscillatory discharge.

line under certain circumstances. It does not generate any ozone at all but causes nitrous compounds to be formed. The spark is an oscillatory discharge. The arc differs in all respects from the foregoing. Its characteristics are the intense heat, the irregular unsteady form, the pale blue color. It is an uncontrolled discharge. It never can nor will generate ozone but causes nitrogen to combine with oxygen, as is known from the processes for the fixation of atmospheric nitrogen.

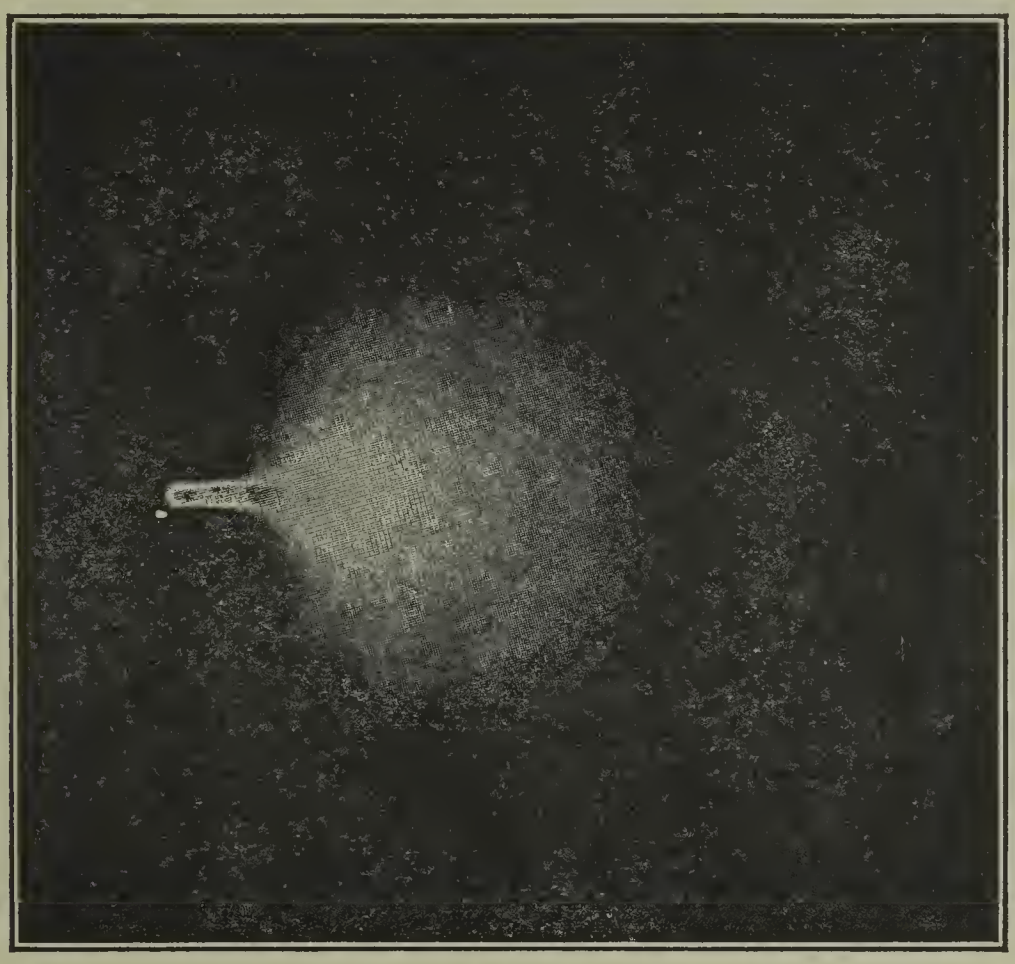

FIG 1.—Positive Brush.

Speaking in a popular way we may say that the brush is an even flow of electricity and if you bear in mind that a spark is a wild rush of accumulated charge, then it is easy to understand that the only thing you have to do in order to have the brush discharge and no other, is to avoid accumulation of charge which, translated into common language, means: use sharp edged or pointed electrodes. The point of a needle is of such a great curvature that a relatively small charge corresponds to a high density of charge, which again means a discharge at low potential. Let us consider this brush more in detail. Fig. 1 is a photograph of the positive

brush. It is a free brush in its best condition and much can be learned from this photograph. In the first place, there should be inequality in the shape of the electrodes; in the second place one electrode should be shaped so as to give the stem a chance of building up or rather to give a support for the stem, and thirdly the discharging points must not be too close together so as to allow of the spread out at the base. All this requires the use of a sharp edged or pointed electrode, discharging against a flat one.

As I disagree with most people on the point of polarity, maintaining that it is the plus and not the minus that discharges as a brush, I will show you the photograph of the minus discharge. I have overwhelming evidence that I am right and have demonstrated

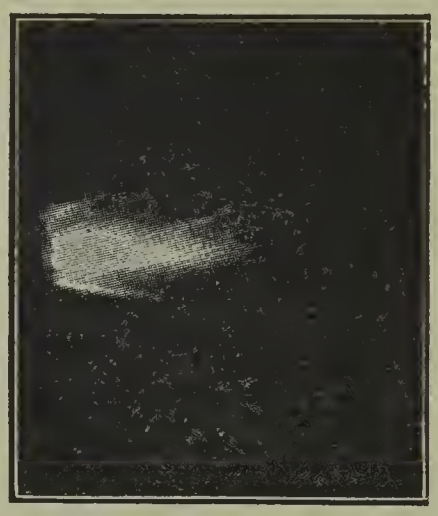

FIG. 2.—Minus Discharge.

it many times, but it takes a long time to correct wrong statements. It would lead me too far from the subject were I to explain this further. I may add that I attribute many a failure of ozonators to the non-observation of the fundamental rules governing the electric discharge.

Much might be added yet as regards details of both practical and theoretical importance but as I have not to speak about discharges but on ozone I will just only remind you that you should distinguish between the different named discharges. They are so vastly different in appearance and nature and character and effect that mistakes ought not to be made. It is essentially the brush that changes oxygen into ozone. For easy comparison I here give the spark discharge as photographed and one mixed with brush.

Up to now we have considered only the case when the electrodes

are separated by nothing but air, but let us see now what happens when some solid dielectric is placed between them. It makes the problem much easier to handle. Hardly any of the difficulties that present themselves when having no dielectric come in. Instead, there appears a new one, viz., the question of dielectric, which we shall discuss presently. Any size or form of electrode will do now, any polar distance, any current, any current density, or voltage above a minimum of say 7000. Two electrodes no matter what or how they are will discharge electricity as a brush, or kind of such, when connected to a high tension source of electricity; but it goes without saying that not every arrangement will give the same economical

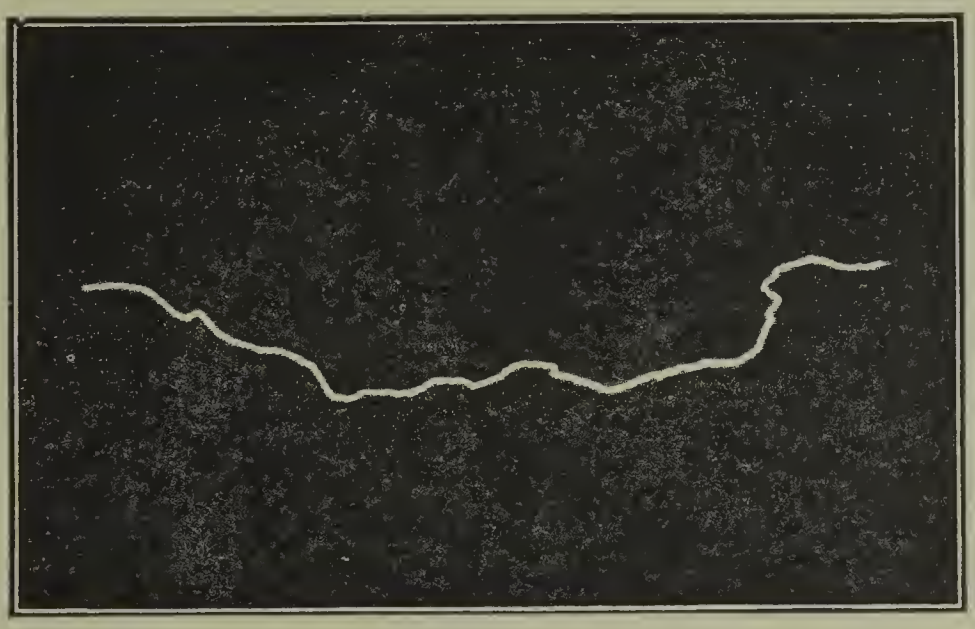

FIG. 3—Spark.

results. As stated, the difficulty comes in with the dielectric, for although there are quite a number of these, there are but very few that can be used. In fact only one is used, that is glass; but glass is a rather treacherous material, unreliable and hard to specify. It is a substance that is never in molecular equilibrium and the combined strains put on it by the heat and the dielectric displacement currents, which indeed put a severe stress on it, and which moreover cause heating again, are causes for failure. Fortunately the modern glass industry is capable of supplying glass of prescribed properties, so that it may be when the demand is there the glass works, or one of them, will be able to make a glass that stands the severe test. As it is for the present the best policy is to try different kinds and specimens and keep the good ones for use. It is the potas-

sium lime glass that suits the purpose best and when ozonators are not taxed to their utmost capacity and worked properly they do the work satisfactorily.

I do not intend to have all ozonators pass in review. There are about a hundred U. S. patents but nearly all of them come down to the use of a solid dielectric between electrodes and the only difference between all those patents, most of which are of no practical value, is a difference in the arrangements of details of construction. One may use glass cylinders or tubes or planes. Electrodes may be wire, or wire gauze, or sheet metal or anything else. It is only a matter of careful design not forgetting the

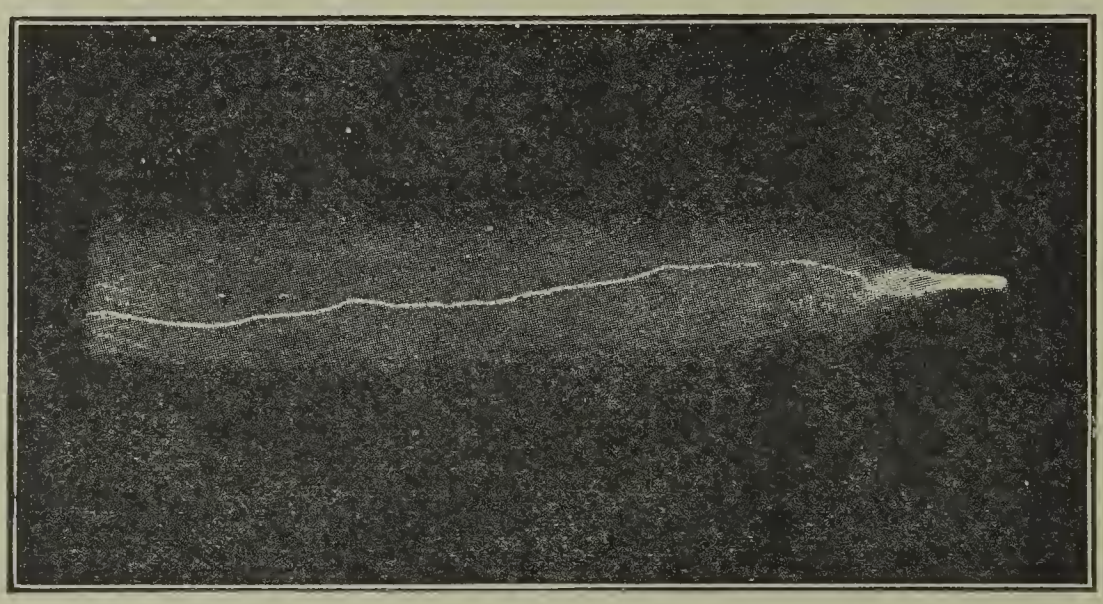

FIG. 4.—Spark Mixed with Brush Discharge.

knowledge of the subject in order to obtain a good ozonator. Absolute ignorance of the subject has given birth to many a queer patent, valueless of course to whoever buys it.

There is another point of importance, that is the question of concentration of ozone. Some industrial applications ask for a high, others for a low concentration and that also influences the choice of type of ozonator. As it is cheaper to make a weak concentration than a strong one, it would be bad policy to make the latter and dilute it with air. For strong ozone one has to have a small polar distance and as high current density as is practicable without endangering the life of the apparatus. To quote a couple of good specimens of ozonators for high concentration I will select the Siemens & Halske type, as the one which has stood a long test in actual work on a large scale in Europe, said firm

having been engaged in the study of ozonators since Werner von Siemens made the first commercial type, some 50 years ago I guess. Another type of good repute is the Gerard, the practical outcome of the original Berthelot tube which in itself is excellent but not meant for anything else than use in the laboratory. Dr. Linder also mentioned these two types in his paper (Trans. V. III. p. 188). The Siemens ozonator has the peculiar and ingenious device of using the cooling water as one electrode, in this way combining a very efficient cooling of electrode and the dielectric in one. The Gerard ozonator establishes effectual cooling through the aid of oil, which is rather an unpleasant substance to have to deal with, though we are used to it in high tension work.

The yield in grams of ozone per KW hour varies according to the concentration but may reach as high as 80, but as a rule is something in the neighborhood of 50 which is pretty good indeed. Small laboratory apparatuses may run up to even more than 80 and at high concentration too, but that of course is a different proposition to working on a commercial scale all day long. Theory admits of an output of over a thousand grams per KW hour, so we cannot claim that ozonators work economically, as far as that goes, and yet we are satisfied for the present.

As said before, of all the different systems of obtaining brush discharges for the purpose of ozone making none but that using a solid dielectric between the electrodes has been able to hold its own. I may add here that I have spent over ten years in the study and construction of a non-dielectric ozonator, but though with much grief, I must admit, to have done so only to find out at the end that I could not beat the old system. I had to give up mine instead of the better, which is rather a poor recompense for so much labor, money and time spent, but facts are facts and take no consideration of personal ambition and vanity.

Among those types of ozonators more especially intended for the production of very low concentrations of ozone, say for ventilating purposes I wish to mention the Vohr type which has the merit of being a handy and trustworthy little machine. The Hudson Ozone Machine Company, who make these little ones, also put larger machines on the market for other purposes and for higher concentration. There are other ozonators which have found large application, i. e. those of the G. E. Company. After all there is not so much diversity in ozonator types. They differ merely in

details and those we cannot discuss now because that is purely electrical matter. For one thing I may warn, that is, do not look only for efficiency. That is a mistake. There are a good many other items of importance such as reliability, ease of handling and cleaning or repairing, prime cost, effect on circuit, etc.

We come now to the second part, viz., the properties of ozone. That could be stated in just one word, oxidizing; but that would hardly be fair because its power of oxidizing is something extraordinary, perhaps best understood by just thinking of its being able to oxidize silver rapidly so that a strip of silver may be used as a detector for ozone. It turns brown at once. Knowing this, it seems quite superfluous to say that ozone will oxidize ferrous compounds into ferric, mercurous into mercuric, etc., but what is remarkable again is that it will oxidize organic ferrous compounds as they occur in water into ferric hydroxide and that it will oxidize the organic matter in solution in waters. Whether or not its highly remarkable power as a bactericide, unequalled by any other agent, is a specific property or merely oxidation is an open question. Some say it coagulates the bacteria and does not act upon spores. Whatever it may be, it is most wonderful and of high importance. You, who are familiar with the bactericidal power of bichloride of mercury, know that of this agent about one in a thousand is required to do the work, but with ozone one in a million is quite enough. Over and over again have I sterilized water, one cubic meter or 1000 kilograms or one million grams with but one gram of ozone diluted in one cubic meter of air and I feel certain that this quantity of ozone could be reduced tenfold if, instead of ordinary water carrying organic matter in solution, I had taken pure water with little or no organic matter. I shall refer to this in the next part again.

Pure ozone is a faintly blue gas the color being shown only when in a thick layer. When liquefied at minus 119° and at 125 atmospheres it is a dark blue liquid of great mobility, very explosive and more strongly magnetic than oxygen. Pure ozone, however, is a very rare compound. When we speak of ozone it is always understood that ozonized air or oxygen is meant, the ordinary concentration being no more than about 4.5 grams per cubic meter of air. As a rule its concentration is less, something like 1 gram per cubic meter and for special purposes as little as one thousandth of a gram per cubic meter is taken. A mistake very often made

is to take these figures for percentages. A cubic meter of ozone would weigh about 1800 grams which brings the contents of ozone in regular work down to 0.05 to 0.25%. Higher concentrations can be obtained in the laboratory. 168 has been recorded but in technical work some 20 or 30 seem to be the most. Ozone is so extraordinarily powerful that you do not want any higher concentration than 5 grams at the most. I feel certain that you will all agree with me on the point that the efficiency of ozone is something out of the common.

It is rather difficult to make ozone and when you have it, it is difficult to keep, ozone being unstable. The rate of decomposition increases rapidly with rise of temperature. Above 270° C it hardly exists at all. There is no chance for ozone ever to be sold in bottles like carbonic acid but there is no need for that either, because it can easily be made on the premises in any quantity and quality.

The peculiar odor which gave it its name has very often been compared to some other. Some compare it to that of chlorine. Others again say it is more like sulphurous acid. In fact there is not a bit of resemblance at all. Ozone smells like ozone; that is all. There is no similarity of smell with anything else. Its name has been another point of unnecessary trouble. Some call it activated oxygen. Others speak of condensed oxygen, or electrified or polymerized oxygen. None of these names suit the purpose. Ozone is ozone and nothing else. It is not a kind of oxygen at all. It is a definite substance of its own, more active than oxygen on account of the loose binding of that third atom or probably of all three atoms. It is not electrified but as neutral as oxygen. It is not condensed though it may contain traces of O_4. It is not polymerized either though it may contain some O_6. Ozone is ozone and is O_3 or, if you want to be correct then turn it around and say O_3 is ozone, leaving out the O_4 and O_6.

Part Three will be devoted to the uses of ozone. There are only a few at present but there may be a good many in the near future especially if you chemists will take more notice of the wonderful power of ozone.

In the foreground stands its use as a purifier and sterilizer of drinking water. Bear in mind now that the product of decomposition is oxygen, any excess of ozone also going back to oxygen and that means something different from an excess of chlorine, or hypo or coppersulphate or iron chloride or lime when it comes to

drinking. The treatment of water by ozone is very simple indeed; in fact it is far too simple for that is the reason that every layman thinks he can do it. That, however, is a big mistake, for although it is simple yet it requires some knowledge of the subject, and skill alone cannot accomplish here what is wanted. In his report Mr. Spaulding attributes many failures of ozone plants to faulty engineering. I quite agree with him. The action of ozone on water is remarkable, but it is also a fact that in order to accomplish it there is one more thing needed, and that is *time*. It does take some time to do the work and that is a point overlooked by most people because they do not realize its importance. All one has to do is to bring the water into very close contact with the ozone and to prolong this contact for several minutes, according to the quality of the water. A long time of contact is the only secret about success. Do not forget that ozone does not dissolve in water to any appreciable degree so that where molecular contact fails we have to compensate for that through prolonged *time* of action.

The ideal apparatus should, therefore, be such as to guarantee an intimate contact with every particle of water and allow a time of contact of several minutes. The apparatus fulfilling these implicit requirements is very simple; so simple that few people realize its beauty unless they watch it at work. It is an improvement on the old chemical wash bottle adapted for technical use on a large scale and made for continuous work. This very simple yet very effective mixing apparatus, generally called the sterilizer has given great satisfaction. Its work is, I would like to say, perfect. It merely consists of a tower or standpipe of suitable diameter and suitable material. Water is let in at the top (1) and runs out at the bottom (2). Ozone comes in at the bottom (3) and the air escapes freely from the top; (4) that is all. For practical reasons this standpipe has to have a height of say 20 or 30 feet. Now by regulating, by means of a common outlet valve (2), the quantity of water that is passing through in a certain time, you can make the time of contact with ozone as long as you like, depending on the quality of the water. See Fig. 5. For ordinary surface water I take 4 minutes, for bad water 8, for good water 2 minutes. This by way of example, the qualifications fair, good and bad, referring to the amount of organic matter present. Evidently the quantity of water treated per time unit (that is the time of contact) can

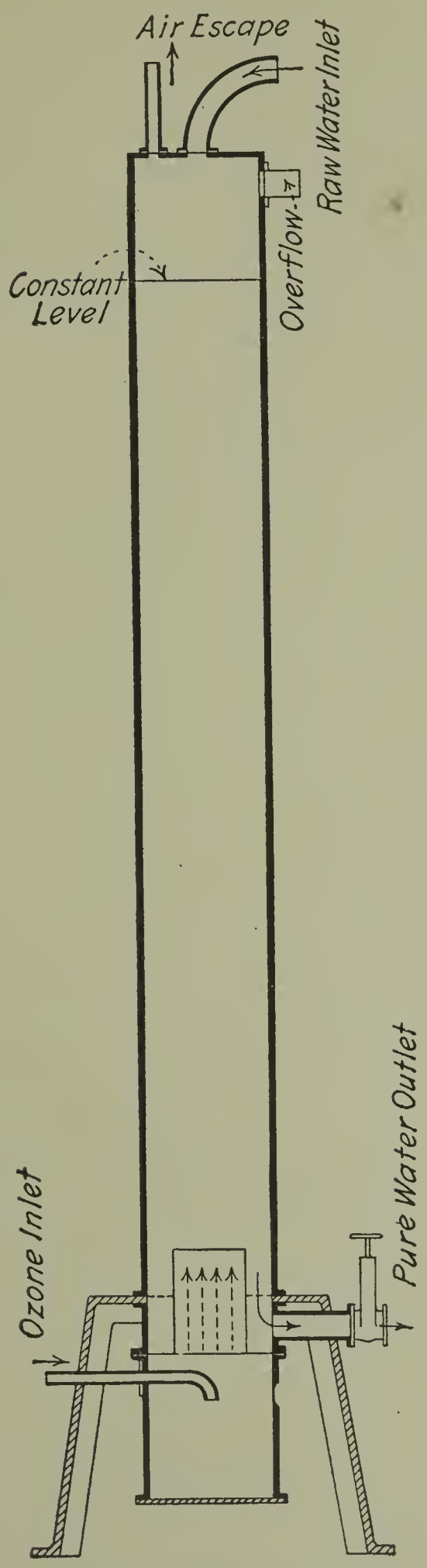

FIG. 5.—Ozonizing Tower.

be regulated from infinite down to any practical value, according to whether the outlet valve is closed or open. Of course, the quantity of water treated also depends on the diameter of the standpipe but it goes without saying that there must be true harmony between all the different factors of work, namely, quantity of water to be treated, quality of same, diameter and height of mixer, quantity and strength of ozone forced into, capacity of ozonators, etc.

In order to have a perfect mixture it is necessary to have a large volume of gas so as to fill up the entire cross section of the tower. Some of you might expect that the ozonized air being pressed in at the bottom, would move upwards as one large bubble, but that is not the case. On the contrary, if you press it in through a large aperture the big bubble at the point of entrance is split up into numerous small ones before it has traveled 5 or 6 feet. This is exactly the same phenomenon but reversed as the well known splitting up of a stream of water into drops. We have just the same question of (inside) surface tension here, and a very interesting case of it too, the size of the individual bubbles varying according to the height. Of course they are a bit larger at the top than at the bottom, but not so very much. Their average size is about ¼ inch. I rather regret that this apparatus is so very simple indeed, because, as a rule, one has more success with some complicated arrangement than with simplicity. The average onlooker is struck more by moving and noisy machinery than by a dead calm standpipe that, once regulated keeps its level absolutely constant. For demonstration purposes I used to perform the sterilization in a standpipe built up of glass cylinders, one foot in diameter, 33 feet high. The absolute mixing could be seen and watched and all doubt taken away. It really was a sight.

Allow me to call your attention to the difference between this apparatus and the ordinary scrubber. Here also there is a counter current but the great objection is that, although the downward flow of the water be somewhat retarded by the coke or gravel, still one cannot regulate that in any other way than by increasing the height of fall, but that does not affect the upward motion of the gas. Whereas in the other apparatus the downward flow of the water can be made such as to nearly check the upward movement of the gas. In case of water at rest the upward speed of the gas bubbles is simply a function of the viscosity of the water depending

a bit on its temperature; but when the water has a downward speed this is opposed to the upward speed of the gas and that is a very important additional means of increasing the time of contact. In actual practise, when all details are in harmony, there is not the slightest tendency of gas bubbles to go off with the water, provided

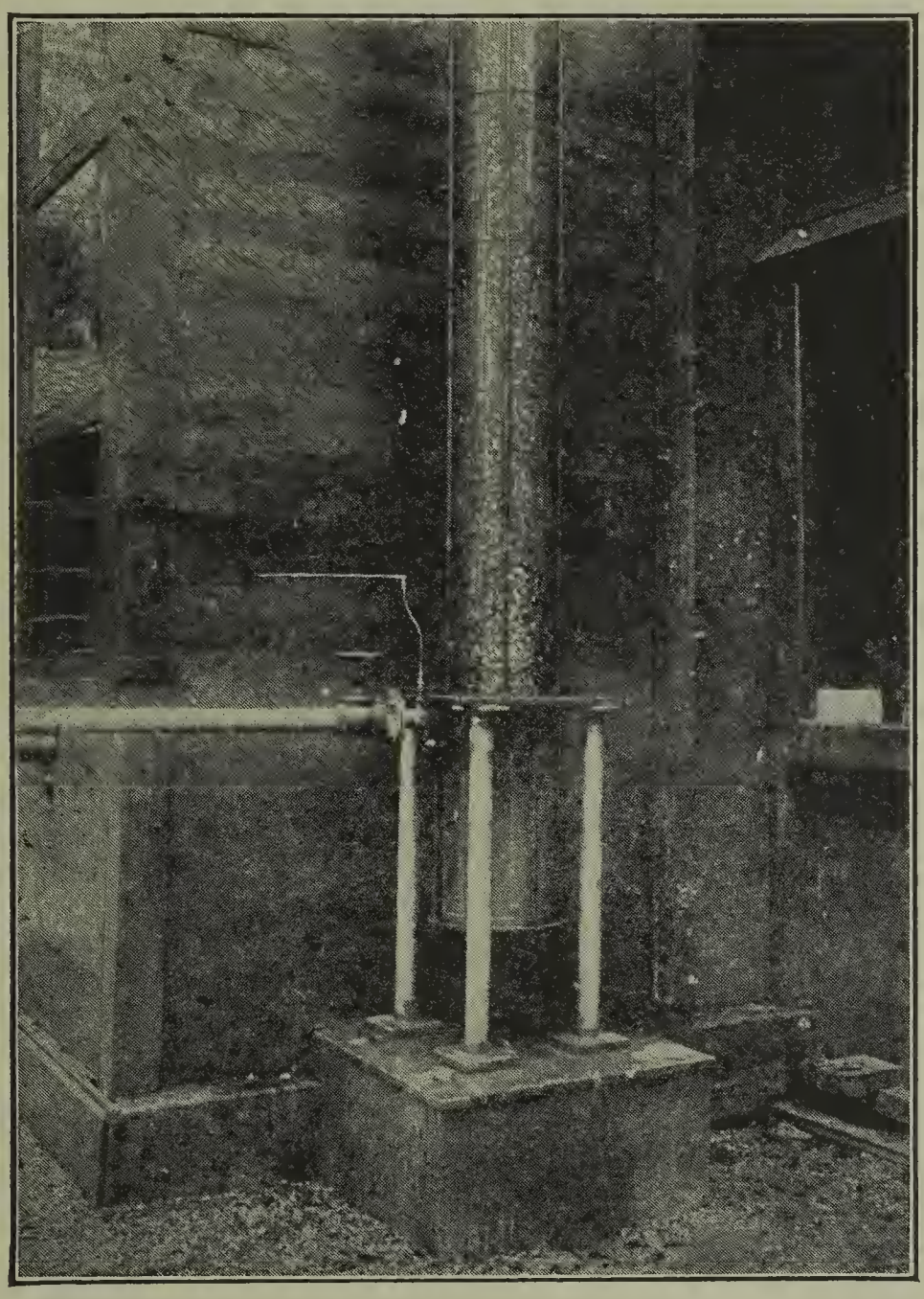

FIG. 6.—Glass Ozonizing Tower.

they have a speed of their own.* The way to have this condition fulfilled is to shield the ozone entrance from the water exit, that is, have this latter at a level below the former, say one foot. I may add that I have been working with this kind of apparatus for

* A perforated screen 5 prevents the water from entering into the ozone entrance compartment, the shield 6 separates the water outlet and the ozone inlet.

several years in succession. I have made them of different diameters, from 6 inches up to 6 feet, ranging in height from 10 feet up to 45 feet and I am willing to guarantee absolute satisfaction. Figs. 6, 7, 8 and 9 are some views of apparatus at work.

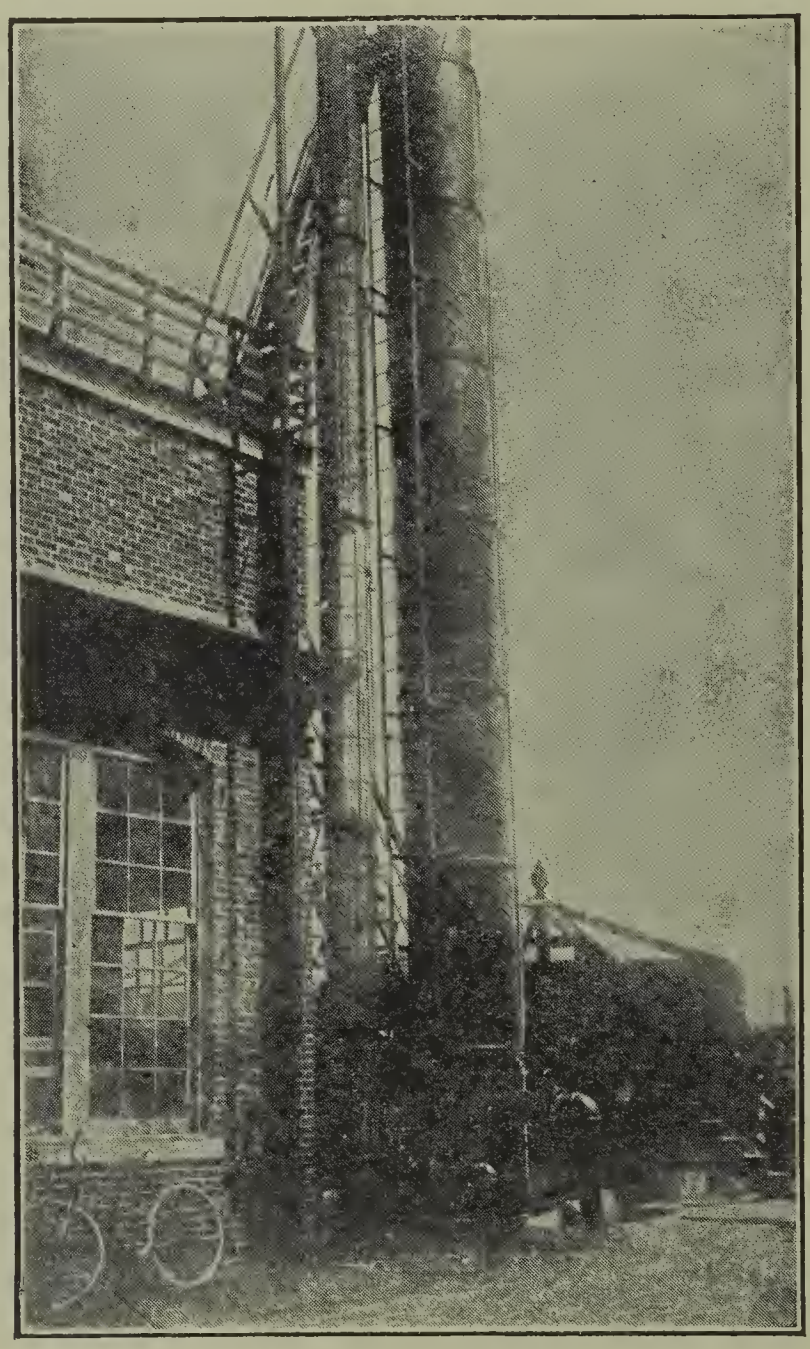

FIG. 7.—Ozonizing Tower.

Another kind of mixing apparatus is the Otto emulsifyer, a kind of injector. It certainly has the advantage of absolute simplicity but also the disadvantage of not allowing of close regulation of the ratio of water and ozone and what is more important the time of contact is reduced to a minimum instead of being a maximum. To make up for these defects one has to use much stronger ozone and much more of it and have some after treatment as well.

Another type, popular among laymen that do not know what has to be done, is to produce a spray of water in a large compartment filled with ozone, said spray to be caused by what is known as an atomizer. Here again we meet with the same drawbacks, insuf-

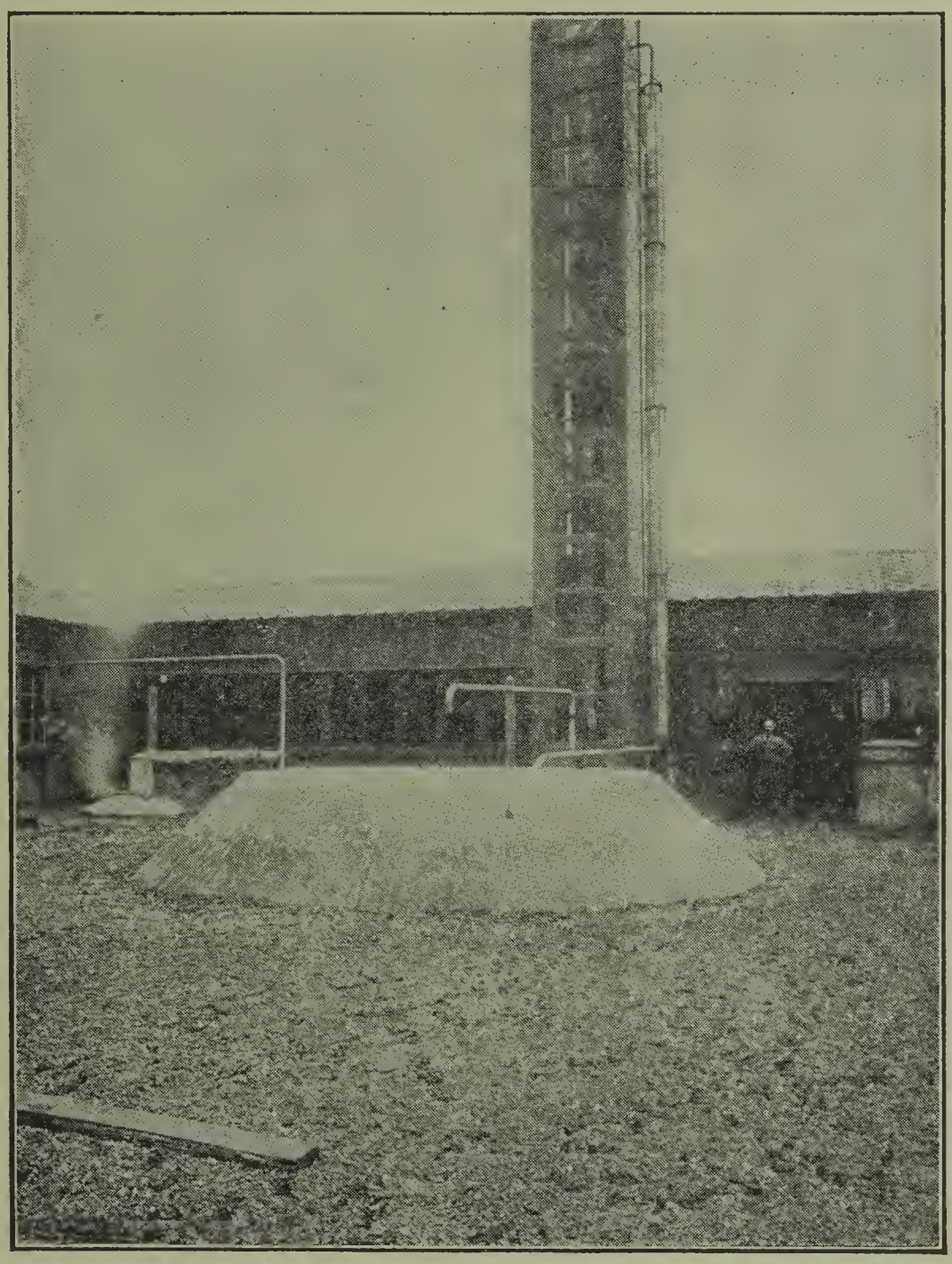

FIG. 8.—Ozonizing Tower.

ficient time of contact and no convenient ratio between water and ozone and insufficient contact also.

I wish you to understand that the purification of water by ozone leaves nothing more to be desired. Ozone will take care of any number of bacteria, selecting those that are harmful and dan-

gerous for human life first of all. Both the typhoid and the cholera germs offer very little resistance. They yield first and what after all may be left untouched are the absolutely harmless *b. subtilis,* and *b. mesentericus* and some spore forming kinds but

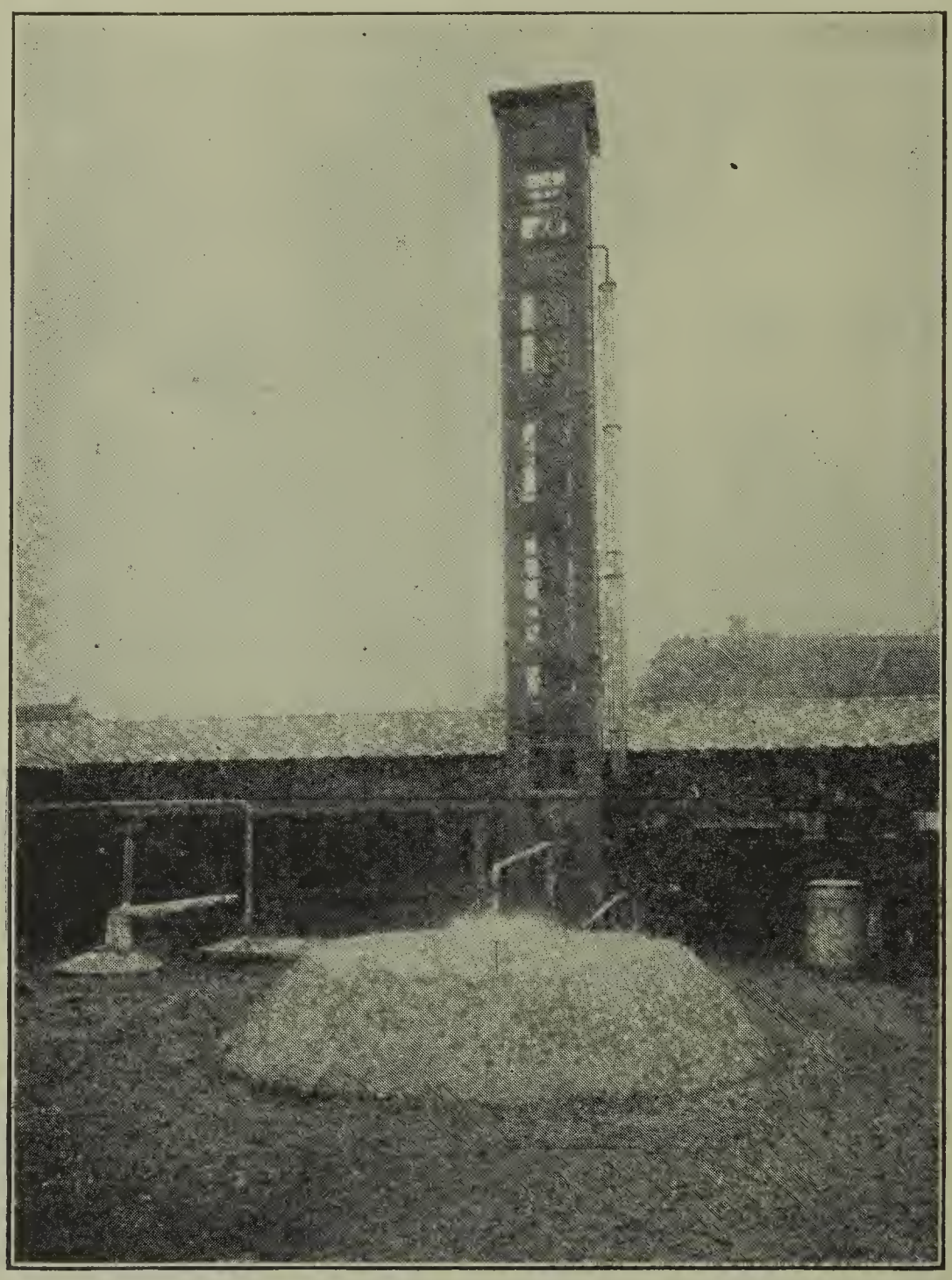

FIG. 9.—Tower in Operation.

they are absolutely harmless. Ozone takes out any discoloration of the water, even that caused by organic iron compounds (ferric). It removes all bad taste if there is any, and it renders a water perfectly clear, pure, colorless, carrying some excess of oxygen which gives a fresh taste. Can any other chemical claim that much?

Now there is only the question of cost left out up to now. This, of course, is of great importance, though often exaggerated because where it concerns questions of health, for instance, typhoid fever with a 10% death rate, we should not mind spending a trifle more to guard against illness.

Modern ozonators yield about 50 grams of ozone per KW hour and as it takes about one gram of ozone to treat one cubic meter of water or say 250 gallons then it takes 4 kilograms per million gallons and that requires say 80 KW hours. Now the price of a KW hour, not bought from some company but made on the premises, and made 24 hours a day, may be something like two cents and that means under the most favorable conditions as little as one and one-half a dollar per million gallons of water. You will certainly not consider that prohibitive. Of course to this figure must be added items for general expenses, pumping, management, interest and depreciation, etc., but these are engineering problems and depend greatly on the size of the plant, its location and the skill of outlay, so no definite figures can be given. There is, however, plenty of margin between the quoted one and a half dollar and a price that would be too high for general use. For fear there might be somebody among you who, knowing the cost of pumping water to a height of 33 feet, is going to add that figure to the cost price, I will call your attention to the fact that the standpipe can very well be put in a pit say some 25 or 28 feet deep. Then the loss of head due to friction is only 8 or 5 feet. Or the available pressure at the water outlet may also be utilized in some other way, but time does not permit me to enter into these purely engineering details.

The next best thing to pure water is pure air. There has been some stir about this matter lately because some doctors are opposed to the use of ozone; but that evidently is a misunderstanding between the parties. We never claimed ozonized foul air to be better than pure air from the mountains or ocean. We never claimed ozonizing the air to be better than ventilating. Neither did we maintain that ozone, strong enough to kill a guinea pig would be specially good for human lungs. Scientific ozonists never claimed to be able to sterilize dry air so it seems quite useless to contradict statements that were never made by competent people related to the ozone business. Medical professionals should distinguish between the claims of competent experts and those of

salesmen who certainly exaggerate the benefits of ozone. Fortunately the matter of the effect of ozonized air on nasty odors has been settled in a highly satisfactory way by Dr. Franklin in his articles in the *Heating and Ventilating Magazine* of November and December. Dr. Franklin also pointed out that no sensible man will ever think of supplanting ozonation for ventilation but the idea is to have it in addition to the supply of air, one advantage being that in order to have a fresh atmosphere in the room, less outside air is wanted because the ozone takes care of the bad smells and odors and the direct advantage being that ozone certainly has invigorating power. There is no question about the capacity of ozone to oxidize organic volatile matter which may be harmless but surely also unpleasant. Products of respiration, perspiration and other decompositions cause an unpleasant feeling. This again causes us to breath less freely and deeply than if the air does not carry any foul smelling matter. So even if ozone did not oxidize, a very improbable supposition, even then it would be beneficial. We must not lose sight of the psychological effect on physiological processes.

But it should not be necessary to point out that the degree of ozonization should not be such as will kill guinea pigs. It should be very far from 20 parts per million and should never exceed one in a million for a long period and should rather be one in ten million for continuous breathing. After Dr. Franklin's excellent article on ozone and ventilation, little else can be said in favor of it and it is to be hoped that whenever medical men again report on ozone, they may first of all examine the points claimed by scientific workers in the line discussed and not fight against fantasies of their own.

In the industries, ozone is not made use of on a large scale, partly because of some failures, partly because few people know enough of chemistry and electricity and mechanical engineering to know how to apply it in a given case and partly also because it *was* too expensive. The book of de la Coux, and many other *commercial* publications, enumerate a good many applications of ozone. I guess, however, very few of these have ever been carried out or at least have been successful.

It is a common mistake among inventors that they claim too much. In this case it has caused much discredit. Ozone will be able to do some good in therapeutics but if you claim that it will

sterilize dry air, all physicians and scientists will turn against you. If one claims that ozone can advantageously be used for steam raising in boilers because O_3 is so much more active than O_2 for burning coal, or if one claims that ozone will sterilize milk or butter, age wines and do such like delicate materials any good, those who know better will simply laugh or smile. There are, however, some industries that will be greatly benefited by the use of it, not in a pecuniary way because ozone is cheaper, but in the way of improvement of product. Such is the case where the bleaching of paper pulp is the object. Of course, chlorine is much cheaper, but the ozone bleached pulp has a better quality, the fibre being much longer.

Being greatly interested in the development of the ozone industry, I shall be very careful not to exaggerate its importance. Experiments and trials are wanted first of all. It is up to the industrial chemists of to-day to see what they can do with ozone since it is a fact that it can be made in any strength up to say 30 grams per cubic meter, and in any desired quantity. Ozone is as yet not intended to play a role as a competitor in price with say chlorine, but it does when one also considers the question of quality of product. In this assembly of chemists I need not lay stress on the fact that any excess of ozone is rapidly removed by auto destruction and that the product of decomposition being oxygen and gaseous it will also be easily disposed of. I have a firm belief that within the near future a good many chemical industries specially the organic, will use ozone, but it will take earnest and able men to carry that into effect. I sincerely hope that there will be such among my audience.

APPARATUS FOR DETERMINING NON-CONDENSING GASES IN AMMONIA

By F. W. FRERICHS

Reprinted from Bulletin containing Proceedings of Fifth Annual Meeting of Trans. Chem. Engrs., held at Detroit, December 4 to 7, 1912.

Dr. W. D. Richardson has published in the Journal of Industrial and Engineering Chemistry, Vol. II, No. 3, March, 1910, some methods for testing commercial liquid anhydrous ammonia. Richardson was the first to call attention to the fact that considerable amounts of non-basic gases (mostly air), are sometimes found in the gases lying above the liquid ammonia in shipping cylinders, which are filled only to 85% of their volume, 15% free space being left to allow for expansion by heat, and that small amounts of such gases are always found dissolved in commercial liquid ammonia.

The Richardson test requires a large and unhandy apparatus, about 1,000 c.c. of normal acid solution and about one hour's time for every test.

To do quicker and equally accurate work a compact apparatus was designed by which a cylinder containing ammonia may be tested in less than five minutes' time, using only 58.8 c.c. normal acid solution for every test.

The apparatus is readily understood from Fig. 1. It is operated as follows:

Place the apparatus in an upright position, close faucet *C* and turn faucet *D* to the position indicated in the drawing. Remove the rubber stopper *G*, fill the tumbler *I* two-thirds full with water and pour standard sulphuric acid solution previously colored by some indicator into tube *B* up to about one inch above the 58.8 c.c. mark.

By opening the faucet *C* part of the standard acid solution is transferred to *A*, care being taken that the straight channels in tube *E* and faucet *D* are filled with acid solution. By sucking on the tube *F* the graduated part of tube *A* is filled with acid up to the faucet when faucet *C* is closed.

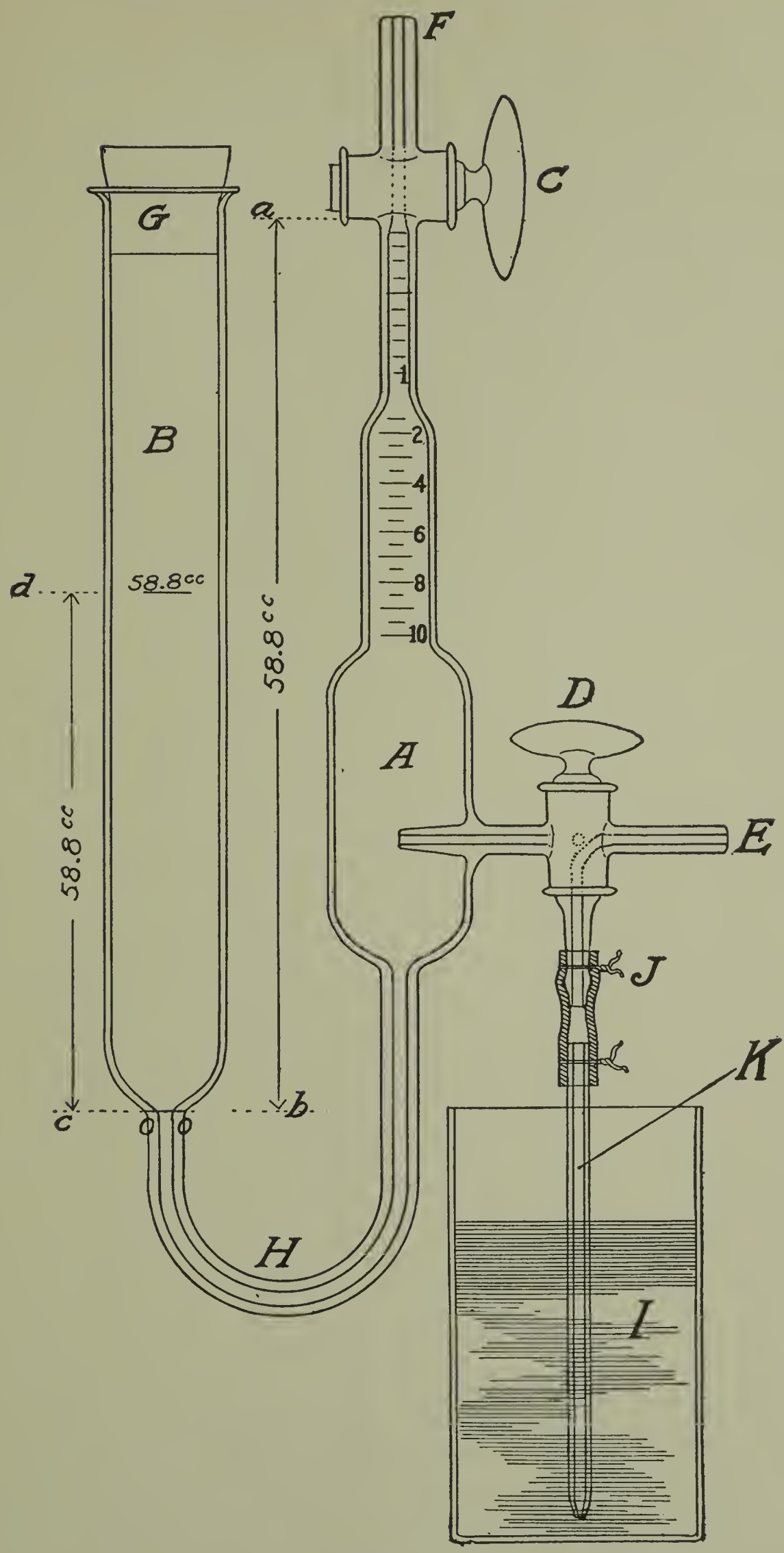

FIG. 1.

The excess acid remaining in tube *B* is poured out by tilting the apparatus and distilled water is poured into tube *B* to fill it about one inch above the zero mark.

A needle valve is attached to the valve on the ammonia cylinder, the outlet of which is connected to nozzle *E* of the test apparatus by means of rubber tubing, which is securely fastened at its ends with copper wire, whereupon the apparatus is ready for use.

For making the test the main valve on the ammonia cylinder is widely opened and the needle valve is turned far enough to admit a brisk current of gas to the test apparatus. When all the air in the valves and rubber tubing has escaped through the tube *K*, the tumbler *I* is lowered until the end of tube *K* is above the water line, whereupon faucet *D* is quickly turned, admitting the ammonia to the acid in tube *A*. When the acid is saturated, which is observed by the turning of the color of the indicator, the faucet *D* is turned again into the position indicated in the cut and the needle valve is closed.

Any air which may have been in the ammonia accumulates in the graduated tube below faucet *C* and its volume may be read off from the graduation.

The amount of ammonia required to saturate the 58.8 c.c. standard acid solution in tube *A* is one gram and the air found in the graduated tube is the number of cubic centimeters in one gram of ammonia.

Stopper *C* serves to close the apparatus while not in use.

This test is only approximate. For accurate work the standard acid solution must be freed from air by boiling immediately before it is used, and after saturation with ammonia must be transferred to a flask and neutralized exactly by the standard acid solution, whereupon corrections are made in the well-known manner.

If ammonia is tested which contains more than 10 c.c. of air per gram of ammonia a weaker solution may be used and the air contained in a fraction of a gram of ammonia may be ascertained by the same apparatus.

St. Louis, Mo., December, 1912.

THE PRESENT STATUS OF THE WOOD TURPENTINE INDUSTRY

By E. H. FRENCH and JAMES R. WITHROW

Read at the New York Meeting, December 12, 1913.

In treating a subject that has as many phases as this one, it will be necessary to discuss briefly an allied industry, namely, that of Gum Turpentine as distinguished from Wood Turpentine, in order that the reasons calling for the development of this latter industry may be seen with the proper perspective.

That the wood turpentine industry is at present at an extremely low ebb is unquestionably true. Nevertheless, it is likewise true that its scientific development is an economic necessity for certain localities, in order that waste may be conserved, that the products from waste replace those from the fast disappearing pine and fir forests and that cut-over land may be cleared at a profit instead of at a loss. Therefore, in this instance, as is often the case, necessity compels development.

The fact that thousands of dollars have been expended and lost in the incubation of this industry has been due, in our opinion, to three main causes, any one of which in itself would account for failure; first, the lack of practical scientific engineers experienced in this or analogous fields; and second, financing for the sale of stock and securities rather than product, and third, lack of efficient marketing organization. It must also be borne in mind, that owing to the number of different processes, there was caused a lack of uniformity of product, which naturally tended to increase selling costs. Except to the U. S. navy, little, if any, wood turpentine has been sold on thorough specifications. There has as yet been no real attempt by manufacturers to effect a general standard, although a few years ago the producers of the practically defunct steam process turpentine, did make an attempt to standardize their product.

One of the important influences that tended at first toward the development of the industry, and later proved extremely detrimental, was the speculative nature of the naval stores market. This was made up entirely of gum turpentine and rosin, upon the prices

of which the relative wood turpentine values were determined. This market in the past has been subject to violent price changes, a fluctuation of from 30 c. to over $1.00 per gallon having been experienced, and this was due almost wholly to speculation. Naturally, therefore, during the upward swing of prices an unnatural development occurred, and plants using costly processes and with inefficient management were profitably operated and exploited. It followed, of course, that when the national government, through criminal prosecution, put a stop to excessive speculation, a corresponding reaction occurred ruining many concerns which required abnormal prices for financial success.

Unreasonably high prices not only encouraged the development of the wood turpentine industry, but also caused an expansion in operations by the gum turpentine manufacturers, so that a larger percentage of trees, and many very young trees, were boxed, causing over-production.

Gum Turpentine

The method of producing oil of turpentine from the resins of coniferous trees, consists in cutting a broad wedged-shaped notch or cup at the base of the tree and removing the bark immediately above the notch for about 18 to 24 inches. The resin exuding from the peeled area runs into the cup at the bottom and is collected from time to time. Each succeeding season the barked area is increased until it reaches about the height of one's head, usually taking five or six years. As many as four "boxes" are thus cut on one tree, depending on its size, permitting only enough of the original bark to remain to prevent the death of the tree.

After collecting sufficient quantity of the resin, it is distilled in a copper still, usually a "fire still," equipped with a live steam jet or a water supply. The turpentine thus produced is not carried farther in any refining process, but is ready for the market. The residue in the still is the rosin of commerce and is barreled at the still. The dross obtained by filtering sticks, dirt, etc., from the rosin is in many places being worked into cheaper grades of rosin. With rosin at an average price, it is generally figured that to make the operation profitable, about 42 c. per gallon must be obtained for the turpentine.

The marketing of the products is done through "factors," as

they are called, that is, companies or individuals who contract with the producers for their output, supply them with funds for pay rolls, etc., and advances when necessary. These "factors" take the product when produced, but usually have no other connection with the producer. Savannah, Georgia, is the leading naval stores center in the world, and usually Savannah prices are accepted as the standard. Jacksonville and Pensacola, Florida, Brunswick, Ga., and New Orleans, La., are also large "factor" centers for this industry.

This method of producing turpentine is generally conceded to give the best turpentine and rosin, but unless more scientific methods are very widely adopted the time is fast coming when it will be necessary to supply these products from another source, for present methods of operation are coming to be looked upon as directly antagonistic to all ideas of conservation under American lumbering conditions, as they so weaken the trees that the loss from windfalls is extremely large. In fact, many large lumber companies have given up "boxing" for this reason, and also because they feel that the growth of the young tree is retarded.

Modifications of the old "boxing" methods are being used in some places. Metal cups are substituted for the box cut in the base of the tree and light clipping is being tried. It is claimed that the loss from windfalls is considerably reduced by some of these modern improvements. At least one large Southern lumber company is at present experimenting on 5000 acre units in order to determine definitely, if possible, the merits of these new cups and other modifications as to yield and influence on windfalls, and also to decide the effect "boxing" may have on finished lumber.

Wood Turpentine

Wood turpentine came into commercial notice about the year 1900. The name was, and is, applied to the product obtained from dead and down timber, a waste product called "lightwood." The live or green wood is not so suitable for this manufacture owing to the moisture content and also to the fact that the bark still remains. Stumps, however, are very valuable, as they contain a much larger proportion of resins than "lightwood." Nevertheless, the cost per cord of stump wood is considerably more, as the stumps usually require the additional expense of removal by ex-

plosives. The cost per cord of "lightwood" at the works will run from $2.00 to $3.00, making, however, no allowance for its value as waste; while stump wood will vary from $3.50 to $5.00 per cord, the price depending on acre stumpage and hauling distances. The manufacture may be divided into five general processes: steam process, solvent process, alkali process, bath process and distillation process.

Before entering into a description of these various methods we desire to emphasize the statement that the manufacture of wood turpentine necessarily will become of far reaching importance in the future. This is for the reasons that it is utilizing an absolutely waste product and is at the same time clearing cut-over lands and rendering them fit for occupancy. We wish also to emphasize the statement already made that many past failures were due to the unreasonable speculative condition of the markets. Abnormally high prices of naval stores induced promoters and unscrupulous persons to capitalize their concerns on the earning capacity during this period, thereby making them "stock jobbing" propositions rather than legitimate manufacturing institutions. This kind of financing, while apparently expanding the industry, really retarded development, as the energies of the management were expended primarily in the office and at the expense of the manufacturing organization.

We have seen from time to time figures of promoters regarding yields and manufacturing costs of the different processes which are not in accord with the results obtained from continuous operations. It may not be entirely without value therefore to cite some comparative yields and operation costs in these different processes. This is especially true since there does not appear to be any published data of this nature. While the records themselves of individual plants would be interesting, such records are often misleading, and in view of actual or possible competition, the location of plants must be withheld.

In submitting data as to yields, values and productive costs, we have compiled them mainly from the actual results obtained during continued operation of a number of large plants. As so many elements making up these figures are variable, owing to location, construction and raw material, our endeavor has been to average them so that a comprehensive idea may be had as to actual results obtained commercially.

Steam process. This process was the first to be extensively

placed in commercial operation, and is very simple in its construction and handling, consisting merely of "hogging" the wood and placing it in a steel cylinder, usually holding about a cord; distillation being carried on with live steam and under varying pressure. However, there probably was little difference in results whether a maximum of five pounds or twenty pounds pressure was used. Distillation was carried forward until oils ceased to be obtained in quantity.

It should be borne in mind that there is a decided variance in the resinous content of wood, therefore it is quite possible to make a selection that would run as high as 30 gallons of turpentine to the cord. We believe the following figures, however, based on a cord of long leaf yellow pine lightwood, weighing 3500 pounds, would be the average:

Turpentine, 9½ gals. at 35 c.	$3.32
Pine Oil, 3 gals. at 35 c.	1.05
Total value of products	$4.37

PRODUCTION COST PER CORD

Wood	$3.00
Labor	1.00
Barrels	.42
Freight (approximate)	.20
Selling Commission	.25
	$4.87

The fuel cost is only the labor of handling the treated chips. However, there is no allowance made for the office, upkeep, depreciation, insurance, etc. Therefore, it can be seen that the steam process necessarily, in order to be profitable, demands a market price considerably in advance of the present markets.

The price of wood turpentine is always a few cents per gallon under that of gum turpentine. The quality of the product produced by the steam process, however, is excellent. Our opinion is, nevertheless, that at least 50 c. per gallon is necessary as a minimum for successful operation.

Solvent Process. In the early development of this process the wood was subjected to the old steam treatment and subsequently treated with carbon di-sulphide for the recovery of rosin. The loss of solvent rendered it impractical. In the next stage of development the wood was hogged and placed in digesters for the recovery of turpentine and pine oil. Then the solvent (a low grade of gasoline) was added, live steam applied, recovering some turpentine, pine oil and solvent by distillation, and the dissolved rosin drawn off, its volatile matter being recovered by distillation. This has been improved subsequently in some instances by omitting preliminary steaming, adding solvent direct and recovering this with the turpentine and pine oil by live steam in the primary distillation, obtaining rosin alone when the still is drawn. The rosin, however, is soft, and difficulty has been experienced in obtaining a hard product, but this is overcome by subsequent treatment. In either method a considerable loss of solvent is always entailed, varying from 17 to 30 gallons per cord. The approximate yields and operating costs per cord are as follows:

Turpentine, 9½ gals. at 35 c.	$3.32
Rosin, 400 lbs. at $4.00 per 280 lbs.	5.72
Pine Oil, 3 gals. at 35 c.	1.05
	$10.09

PRODUCTION COSTS PER CORD

Wood	$3.00
Labor	2.50
Loss in solvent at 15 c. (17 gals.)	2.55
Barrels	.42
Rosin Barrels	.25
Selling Costs	.50
Freight	.75
Total	$9.97

Again the actual fuel cost in this process is negligible as use is made of the "treated chips." No allowance is made here for insurance, upkeep, overhead and interest charges, refining costs or depreciation; therefore, it is plainly evident that at present market prices, at least until improvement is made in yields or in minimizing

costs, there is not sufficient margin for successful operation. However, it is quite possible that by using the "treated chips" for paper pulp manufacture that this process will be made of commercial value. The operation in this case would have to be maintained on an enormous scale in order to supply treated chips for a pulp plant unit of an economic size. A plant using this solvent system and built on a very elaborate scale, was in operation in southeastern Georgia, and, despite the most advantageous financial backing, was unable to operate profitably on a weakened market, and is now in the hands of receivers. This citation alone probably would not necessarily condemn the process, but as several smaller plants are either in like position or shut down, it indicates the necessity of research or development if ultimate success is to be attained. As with the steam process many claims of higher yields than we have above credited are made by interested parties, but these claims are still subject to substantiation.

Alkali Process. This process is essentially one to be applied to the alkali processes for manufacturing paper pulp from resinous woods with the recovery of turpentine and rosin and at the same time improving the quality of the pulp, and promoting ease of manufacture. The process is well covered by patents.

The basis upon which this method rests is the fact that the sodium hydroxid saponifies the resins in the wood and the sodium resinate thus formed may be separated from the spent soda pulp liquor by temperature regulation. The wood is handled in the same manner as in soda pulp manufacture, except that after digestion the spent liquor is cooled for the separation of sodium resinate before this liquor proceeds to the evaporators. This product has been so purified and refined, commercially, as to produce a good quality of paper size. The resinate may, if desired, be manufactured into rosin by acid treatment, or destructively distilled, obtaining rosin oils. The turpentine is recovered from the digester blow-off during the digestion operation. This process is apparently theoretically sound, but requires the outlay of capital to develop thoroughly the mechanical details. Fifty to seventy thousand dollars were expended in one case to demonstrate its commercial possibilities and some results were obtained. However, the enterprise has not been financially successful and the plant has been dismantled, a fact which may be due to faulty engineering or other causes; and even though the process appears enticing from a theoretical viewpoint

the fact remains that the trial was not successful and there is no process of this kind in actual operation. Nevertheless, it is our opinion that eventually it will be of commercial importance and ultimately the combination of the two industries, paper pulp and turpentine-rosin recovery, thus utilizing resinous wood, will be successful. Unusual yields of turpentine are claimed by a Florida plant using an alkali bath, but satisfactory arrangements have not yet been made regarding rosin recovery.

Bath Process. This process must not be confounded with the recently suggested process using a bath or envelope of oil external to the oven for the purpose of heating the same. This external bath process has not been long enough in operation to demonstrate its future and it will be interesting to note if certain fundamental operation difficulties can be overcome.

By bath process we refer to the process commercially so called which has been in operation for some time and in which the bath is *within the oven* or retort in contact with the wood itself. Three plants using this method have been built, the first in North Carolina, which has been dismantled, the others at Mt. Pleasant, Georgia, and Jacksonville, Florida, which have not been successful under low market conditions and both of which have gone into receivers' hands within the last few months.

The process itself was divided into two separate general operations. First, the recovery of turpentine and pine oil, or as styled "sweet spirits," and subsequently the destructive distillation of the wood itself, although this second operation was not contemplated in the original process.

The operation has a decided advantage over the solvent and steam processes in that it does not require the "hogging" of the wood.

The general construction used in this first operation consists of steel cylinders at Mt. Pleasant, and concrete ovens at the Jacksonville plant, each holding five to nine one- or two-cord steel cars, similar in construction to those in common use in hardwood distillation, thus each oven holds about nine cords of wood. Placed at the side of the oven is a heater equipped with a large cast iron worm connected to the bottom of the oven. To the rear of the heater is placed a large steel or concrete reservoir connected by cast iron pipe to the top of the oven and also to rotary pumps which in turn are connected to the heater pipes.

The loaded cars are placed in the oven and melted rosin or pitch is run into the reservoir and circulated by the pumps through the heater and the bottom oven connection. This pitch after filling the oven *in contact with the wood* overflows into the reservoir and is thus continually circulated through the heater and oven, thereby vaporizing the volatile resinous bodies and without dissociating the wood fibre. The turpentine and oil vapors are carried through a "vapor" chamber where the high boiling liquids that are mechanically carried by the vapor are separated, the vapor continuing to an ordinary tubular condenser, where the crude "sweet spirits" are obtained. Afterwards the "sweet spirits" are refined, the products being turpentine, pine oil and a tarry residue. The time required to treat a charge varies in the plants mentioned from seven to ten hours, and the product obtained is of high quality, though not so good as steam process turpentine.

At first sight it would appear that in this process the rosin from the wood treated would gradually increase the volume of the bath and rosin be thus manufactured. The reverse of this, however, is the case, as a serious loss of bath is actually realized. This is in fact a very serious drawback to the process, and is probably due to the formation of volatile rosin oils when the liquid bath encounters the high temperature of the heater. These rosin oils are volatilized and pass into the "crude spirits," and are lost in the refining residue, as only from 65 to 70% of the spirit is received as turpentine and pine oil. By proper arrangement this difficulty could have been avoided.

This process is also seriously handicapped by the fuel consumption of the heaters and the heavy upkeep for heater pipes and pumps. Nevertheless, with proper design, operation costs would have been much reduced from that actually experienced.

After refining, the results from this "sweet process" could be averaged as follows:

Turpentine, 7½ gals. at 35 c.	$2.62
Pine Oil, 2½ gals. at 35 c.	.87
	$3.49

After the charge is withdrawn in this first operation the "treated" wood is placed in ovens similar to those used in the

hard wood industry and there subjected to destructive distillation. The results obtained here are very important as a good market has been created for these products. An average of from 68 to 70 gallons of oils is obtained, together with a like volume of "acid water," the latter a "waste," although its utilization was accomplished just prior to the receivership of one of the mentioned companies. In addition there remains in the cars approximately 900 pounds of charcoal and there is produced about 10,000 feet of non-condensible gas per cord which is of fuel value.

This crude distillate above mentioned is called "destructive distillate" or "D. D. product," to distinguish it from the product derived from the resins, called "sweet spirits." On refining there are obtained the following products per cord:

Tar, 41 gals. at .08	$3.28
Light Oil, 6.8 gals. at .12	.81
Heavy Oil, 10 gals. at .12	1.20
Charcoal, 36 bushels at .075	2.70
From "Sweet Process,"	3.49
Total	$11.48

Costs of Production per Cord

Wood	$3.00
Fuel	3.25
Labor	2.75
Cooperage	1.00
Selling costs	.60
Freights (approximate)	.75
	$11.35

Again it can be seen that this process handled as it has been in the past cannot be operated successfully on a low market, as no allowances have been made for upkeep, insurance, interest charges, refining costs, management or depreciation. Although the loss in both is partially made up by the pitch obtained, it can be seen from these costs that improvement must be had before this process can exist during low market conditions. It is not to be inferred,

however, that the principles upon which the process is based are entirely faulty. The reasons for its failure appeared to be lack of knowledge as to the chemical nature of the products and troubles consequent to improper construction and operation. As is common with approaching dissolution strenuous efforts at improvements were made in this process, and despite well known prior failures, experiments were completed and operation commenced for the utilization of the waste "acid water" just before the closing of one of the plants. The results proved interesting and promised excellent recovery, as the products recovered, including acetate of lime and wood alcohol, represented a net gain of well over $1.50 per cord.

Distillation Process. As the wood turpentine industry now stands, the destructive distillation process apparently has the best chance of commercial success, as it is not only more simple in construction and operation, but yields more in volume of products. Chemical and engineering skill, nevertheless, are necessary for this success.

The distillation process may be subdivided into three divisions. First, that division analogous to hard wood distillation. This method in its primary operation is very similar in equipment and design to the usual hard wood distillation plant, the wood being placed in steel cars and run into ovens. The products derived from the resins and those from the dissociated wood are collected together, and separation is made during refining, although some attempt has been made at fractional distillation in this primary stage. This method gives a much inferior grade of turpentine, etc., owing to the commercial difficulty of eliminating the pyroligneous bodies, and the product will not answer to the permanganate test which indicates pryoligneous matter. The tar produced in this operation is usually resinous and for some uses therefore objectionable.

The second division is merely a modification of this process, the ovens being in duplicate, and distillation for the resinous bodies being carried out in one oven, so designed or "set" that the temperature can be maintained approximately uniform. After the resinous bodies have been obtained the "treated wood" is withdrawn and placed in a second oven and in this oven the distillation is carried at a higher temperature for the destructive distillation of the wood itself.

The third division is that using concrete ovens containing 12 inch heater pipes running the length of the ovens. These ovens

have dutch-oven connections and the flue gases travel through these pipes, and it is claimed that temperature regulation is more easily accomplished.

In all these processes the products obtained are the same, except so far as the degree of purity is concerned.

The first distillate, or that from the resins, in these methods will run on an average 22 to 24 gallons of "sweet spirits." This on refining will give from 50 to 60% or from 12 to 14 gallons of marketable turpentine and from 9 to 10% of pine oil or from 2 to 2½ gallons, and also 100 pounds of a very resinous pitch.

The destructive products are the same as those from the "bath process," thus it can be seen that the gross total in this operation should be materially higher than in the other processes, while the operating expense is very much lower. This, including wood, upkeep and in fact all expense, should not under proper design, construction and management run over $9.00 to the cord.

The particular objection raised against the destructive distillation process is that the products are difficult to market, and this has been true, to a certain extent in the past, but when it is considered that many of these bodies were new to the trade this condition cannot be wondered at, and at present the marketing is not more difficult than of products of other processes. In fact, just now there is an unusual demand for these products.

Markets

It may perhaps be of interest to call attention to the various developed markets for the D. D. products, for we all realize that the marketing of products is at least equal in importance to the manufacture; and this industry shows many instances where comparative merit of process and operation was wholly lost by inferior marketing facilities, and on the other hand instances in which unsound operation was maintained for considerable time by a remarkably efficient selling organization. The latter cases, while losing ventures to those financially interested, have no doubt succeeded in creating a growing demand for products as indicated by the prices obtained now for them with many plants closed down. At the time this article is written tar could easily be sold for 12 c. per gallon as compared to the 8 c. allowed in the cost data in the article, but which should be considered a maximum, as the future, undoubtedly,

will increase supplies so as to bring these prices back to a more nearly normal condition. This fact, however, does show that a demand has been created that did not exist prior to the quite recent establishment of plants of this nature. Perhaps this condition is more clearly evidenced in the heavy D. D. oil, for which 22 c. per gallon is being obtained. The tar demand had in a measure been previously supplied by that known as "kiln tar" made at works using the kiln system for charcoal manufacture from resinous woods.

The product mentioned as D. D. light oil is at present most difficult to market profitably. This is on the market in this form and is used to some extent by manufacturers of disinfectants. However, it has been fractionally distilled and has been used locally as a substitute for gasoline for use in engines and has proven itself to be more efficient than gasoline. The comparatively small amount of this product makes its use in this manner merely of local interest but it indicates a real value of the product.

The heavy D. D. oil has been in consistent and increasing demand, particularly in the paint industry and notably for shingle stains, and also for the manufacture of tar oils for which there is a large foreign demand. The necessity of an energetic market agency was in one case well illustrated within the past year with this product. One large concern was offering this product for 5 c. per gallon, finding it impossible to market, having nearly 100,000 gallons in storage, while at the same time another company was unable to supply its customers at 18 c. per gallon. Of course, the latter considered the purchase from the former but feared future competition, in case, as seemed dangerously probable, the former concern should learn of their customers.

The pitch produced in the distillation process and distinguished from the tar has a firm market demand from ship chandlers and also is sold for uses such as coating silos, rendering them impervious to moisture.

The tar of course, has its established uses with rope manufacturers as well as with paint producers, while the charcoal consumption, particularly in the south, is very steady both for domestic use and manufacturing. Of the number of suggested specialties based on the use of tars and oils, doubtless a few will ultimately contribute a steady demand for a portion of these products.

Costs of Installations

The various processes have in most instances exceeded reasonable installation costs. Undoubtedly the same is true in any newly established industry, and more particularly in cases where, as pointed out in this one, prices could be obtained that were out of all proportion to production costs.

Entire equipment of a steam process plant should come well within $750 per cord capacity, while the solvent process complete should be approximately $2000 per cord, this also should be approximately that of the bath system, while the destructive distillation method ought to be very close to $1500. In making these general estimates neither working capital nor purchase of timber or stumpage is considered.

Conclusion

When your attention is brought to the fact that the destructive distillation plants alone have been able to survive recent price depression, it is reasonable to conclude that, in the present state of the art, this method has inherent advantages. Nevertheless, in this type of process, there is room for much improvement, particularly in refining and the utilization of waste products ignored in the past. Constructive chemical engineering apparently has in this industry opportunity to create an unusually profitable business, provided it utilizes the unfortunate mistakes of the past, by combining parts of the various processes.

It is not to be inferred from this article that recommendations are made for the encouragement of any particular process, the motive being merely to outline present conditions or, broadly, to show cause and effect, and also to show, if possible, that many elements are as necessary in this industry as in any other, to attain success. Statements have been made to the effect that failures in most instances were due to lack of real engineering skill, and this is partly true, but lack of skill is not wholly accountable for even the engineering failures, for no amount of theoretical engineering skill can replace the knowledge acquired from continued intimate contact with the going operation.

Neither does this statement take into consideration the market-

ing organization, which is also an essential, and is always confronted with the general economic situation, which does not affect directly the operation.

It can be seen from this outline of the industry that its very existence was primarily due to an unnatural market condition and as the field for profit and exploitation was so enormous it can hardly be wondered at that unusual activity was had in its promotion.

November 20, 1913.

DISCUSSION

(COMMUNICATED)

Dr. JOHN E. TEEPLE: Prof. Withrow has presented a very full and fair discussion of the present status of the industry and I think it wise to place such papers on record regarding various industries at frequent intervals.

With his general descriptions and conclusions in the main I have no quarrel whatever, in fact I have already expressed myself to much the same effect regarding several of the processes[1], but I am inclined to think I have a serious quarrel with what seems to me to be the method of "submitting data as to yields, values and productive costs" where "so many elements making up these figures are variable" and "our endeavor has been to average them so that a comprehensive idea may be had as to actual results obtained commercially." Frankly I don't think the thing can be done. Unless we can know in each case how many plants have been "averaged," what the capacity of each, what local conditions were important in each case, what are the extremes of the various costs, yields and prices, we will be far from getting any fair comprehensive idea of the actual results obtained commercially.

To illustrate: Take the first cost statement I find in the paper: "With rosin at an average price, it is generally figured that to make the operation profitable, about 42 c. per gallon must be obtained for the turpentine." Think of the questions such a statement immediately sends through your mind! What is an average price for rosin? Shall we average it for the last week, last month, last year, last ten years, or last twenty-five years, because each method will give a different answer. What grades shall we average, and if

[1] J. Ind. and Eng. Chem. 5, 680 (1913); Met. and Chem. Eng. (4 references), 12, 23 (1913); 12, 75 (1913); 12, 247 (1913); 12, 35 (1914).

all, what respective importance shall we give to the price of each grade? Assuming that we have in some way found an average price for rosin, and can get anyone else to agree that it is an average price, then how do we get the about 42 c. per gallon for turpentine? Why not 39 c. or 35 c. or 33 c. or 48 c. or any other figure of the many that are given us from the South? Then is this 42 c. the price at point of manufacture, in New York, Savannah, London or Chicago, in barrels or tank cars, and is it only for the year 1913 or the last ten years, or has it always been so? In short, this is not "data," is it?

In the figures on steam distillation we note yields given of 9½ gallons turpentine and 3 gallons pine oil per cord, which we pass without comment except to admit that there is wood which would give such yields. It would be interesting, however, to know the maximum and minimum figures which led to this average and whether at all the plants averaged, the wood cost $3.00 per cord. Again, several at least of the steam plants were selling chip residues as fuel netting them in some cases as high as $1.00 to $2.00 per cord of wood extracted. This immediately changes our deficit "data" of 50 c. into a surplus of 50 c. to $1.50 per cord. Still the plants are not running.

In the solvent process figures we start with a cost of $9.97 and an income of $10.09, making an apparent surplus of 12 c. per cord, and as the authors say "at least until improvement is made in yields or in minimizing costs, there is not sufficient margin for successful operation." Suppose we make the improvement in yields by changing 400 lbs. rosin to 600 lbs. and we have increased our income $2.86 per cord with only the stroke of a pen required to do it. As a matter of fact I have never seen regular daily or weekly operation sheets of a large plant showing as low a yield as 400 lbs. gross rosin per cord.

In the bath process our yield of turpentine according to the data drops off 2 gallons per cord, and of pine oil 1 gallon. Are we to interpret this as due to the process, the wood, the foreman, leaky tanks, short weight, high finance, or some other variable? If the statement means that a given wood which yields 9½ gallons turpentine by steam distillation will only yield 7½ by the bath process, and a page or two further on will yield 12 to 14 gallons by destructive distillation, this would be most interesting, and we would like to know more about it. If these were even three definite

figures of yields at three definite plants by different processes, on different woods, under different conditions, we could still use them if we knew the variable factors. But where the figures are only averages, "compiled mainly from the actual results obtained" including we don't know what, and averaged we don't know how, and frequently at variance with our own experiences, how can we accept them as data covering "some comparative yields and operation costs in these different processes?" I just naturally hate to see things compared unless we agree definitely on what we are comparing, and then give all competitors a fairly equal show.

As stated above, in general I have no quarrel with this paper. I think the descriptions are accurate and the conclusions mainly correct. I might take exception to the statements "that the destructive distillation plants alone have been able to survive recent price depression." My own information is that right now more cords of resinous wood are being treated per day by the solvent process for example, than by destructive distillation. But the real point I wanted to bring out is the distinction which we as chemical engineers should emphasize very strongly, the distinction between data and casual description. As casual description some of the figures given might be both illuminating and instructive; as data to go on record, they seem to lack that precision and definiteness of time, place, extent, and condition and specification of variables that we expect in scientific work.

Take any one of the various tables of cost and production given, for example the one on solvent process. I do not suppose it is claimed that this is the record of any one plant spending $9.97 and receiving $10.09 per cord in the ways given for any definite period of time; neither is it probably a combination of figures on any two or six or ten plants over any definite period of time averaged on any definite basis. What is it then? In what way can we call it data? How does it differ from the promoter's prospectus except in degree? I have no doubt that a considerable number of people including the authors could publish interesting data on this subject, but let us not fool ourselves into believing any has been published yet.

January 2, 1914.

FRENCH and WITHROW (communicated): At his request, through the Secretary, we forwarded to Dr. Teeple on December 24th, 1913, our paper read at the New York meeting of the Institute, for discussion by him.

His discussion appears to involve mainly:

1. Complaint as to failure to divulge sources of information.
2. Complaint of lack of completeness of detail.
3. A questioning of the existence of reasons for yield discrepancies between different processes.
4. Disagreement as to the status of solvent process.

(1) *Complaint as to the failure to divulge sources of information.*

We have stated clearly that we were attempting a comparative discussion of the different processes, using average data taken from actual figures of a number of representative plants.

It would be entirely unethical for writers who are not owners of these plants to make public confidential figures disclosing financial conditions of such plants, when such figures were gained through consultation or other intimate private connection.*

Comparative figures conscientiously compiled by men not interested in any one only of the processes are certainly of more value than detailed figures from separate plants each with its own local conditions, although such disclosures would undoubtedly make interesting reading for persons intimately connected with other plants.

(2) *Lack of completeness of detail.*

It is often the custom to criticise from one point of view or another, industrial chemical information when published, and generally on the score of incompleteness. Probably we have all been guilty of just this kind of attitude at some time, but such criticism can obviously make but little for progress in the absence of clear statements in correction or by way of addition.

(3) *A questioning of the existence of reasons for yield discrepancies, between different processes.*

With reference to the well known shortage in yield in the bath process, the existence of which shortage we are surprised to see doubted, as well as other greater discrepancies in yield between different processes in which wood chemistry is involved, we made

* Code of Ethics, Am. Inst. Chem. Engrs. Art. 2, Sec. 10.

no comment because the question is a deep one and little, if any, scientific investigations have yet been published on these questions, in which we have long been interested. A discussion of these chemical phenomena would be out of place here, though we have had the opinion for some time that rather simple chemical considerations might explain at least some of them. For instance, it is very possible that the fact of the turpentine, being in intimate contact with the bath liquid at its high temperature, forms condensation products or polymerizes. This is indicated by the difference in yields obtained between a rosin bath and a pitch bath, the latter containing many of the unsaturated bodies experienced in hard wood tar.

In addition to this possibility for chemical reaction, some products are carried through the system before volatilization can take place, possibly owing to their reduced vapor tension while dissolved in the bath, and are probably decomposed by the heaters. These possibilities are supported by the further fact that rapid circulation increases yield of product by shortening the contact period of the turpentine bodies with the heaters and also by the recovery of small amounts of turpentine when a condenser is attached to the rosin reservoir.

(4) *Disagreement as to status of solvent process.*

The criticism of our remarks on the solvent process gives the impression that we attributed "an apparent surplus of 12 pts. per cord" to it, by quoting in the criticism the *last half only* of the sentence which explains these figures, the criticism quoting as follows: "At least until improvement is made in yields or in minimizing costs, there is not sufficient margin for successful operation" —Whereas: the complete statement in the article reads as follows: "No allowance is made for insurance, upkeep, overhead and interest charges, refining costs of depreciation: therefore, it is plainly evident that at present market prices (Nov. 20, 1913), at least until improvement is made in yields or in minimizing costs, there is not sufficient margin for successful operation."

A similar re-reading of other parts of the original article which have been mentioned in the criticism and incompletely quoted, will make further comment unnecessary.

So far as the statement in the criticism that: "My own information is that right now more cords of resinous wood are being treated per day by the solvent process, for example, than by de-

structive distillation" is concerned, it is misleading, unless we remember that one solvent process company whose southeast Georgia plant was mentioned in our article, alone has a capacity of at least equal to all distillation plants combined. We indicated that in our opinion this process was still so much in the experimental stage, that much still remains to be done before general success can be claimed for it under low market conditions. This opinion has been further confirmed since writing our paper by the fact that information has been made public that an injunction was asked by creditors of the above mentioned company requesting the United States court to restrain the receivers from continuing operations, alleging that such operation was being continued at a loss, thus jeopardizing assets. The receivers admitted the allegations, thereby acknowledging insolvency. Of course this fact would indicate that a production of 600lb of rosin per cord was improbable as this "scratch of the pen" mentioned in the criticism would add roughly $800 per day to the value of the product from this plant.

There are a number of statements in published articles relating to this industry including the references in the criticism, which we do not find to be in accord with our experience. We avoided citing these cases so as to obviate possible controversy which might attract attention to points which were of minor importance to the point of view of our paper, and away from the main issue, which was an economic discussion of the present status of this industry, and in which was incorporated data of sufficient degree of completeness to emphasize reasons for our conclusions.

Our remark regarding "rosin at an average price" to which criticism is made, was in the introductory paragraph on gum turpentine, concerning which we gave no details, as they would be too voluminous and not needed in our discussion. We did go so far, however, as to quote the feeling of the gum turpentine producers, with whom we are familiar, and whose situation was comparable with the wood turpentine plants we used in our comparisons as to their relation to the market as evidenced by their readiness to dispose of their options when prices go below that mentioned.

All chemical engineers know that some plants can live because of various factors, under markets that are disastrous to others, and it is also well known that there is a danger zone in market conditions in every industry where there is little incentive for

expansion or plant construction. The approximate position of this zone we have endeavored to indicate.

In conclusion we may repeat that the paper was an economic discussion with sufficient summarized figures for the purpose in hand, and made no pretension to minutiæ of detail, and avoided absolutely any discussion in the interesting field of the scientific problems involved.

Dr. TEEPLE (communicated): The authors found four things in my discussion. "1st, Complaint as to failure to divulge sources of information." This seems gratuitous. I cannot find any suggestion of this complaint in my discussion, and certainly had no intention of making it. "2d, Complaint of lack of completeness of detail." This is not my complaint either. It is a matter of clearness, not of detail. The question I suggested indicate some of the factors which must be used in determining final figures if the latter are to be dignified by the term "data." It is not necessary that details be published, but if they are withheld we should have assurance what factors have been considered and how. Averages in general are of little value as data unless we know the number of terms averaged and the maxima and minima, and whether different relative importance has been given to different terms. "3d, A questioning of the existence of reasons for yield discrepancies between different processes." This is not the point I question. Of course differences exist between different plants and different processes. My question was, are the differences in yield given by the authors due solely to differences of process as they assume, or are some of the many other factors mentioned responsible. "4th, Disagreement as to the status of solvent process." This disagreement on my part, aside from the same general discussion other processes received, consisted of a parenthetical statement of four or five lines, having no bearing on the general argument. A further discussion of it here might lead us off the trail again.

The whole point I tried to bring out for discussion is this: Are these figures actual averages obtained by good operating plants or not? If they are, they are data. If they contain anything else or have been modified by unknown factors or estimates, they are not data.

I cited a number of cases in my discussion where apparently the statements and figures given lacked clearness and precision if

they were taken as data. Only one more will be cited here. Take the following on "steam process:" "We believe the following figures, however, based on a cord of long leaf yellow pine lightwood, weighing 3500 pounds would be the average." The average of what? Average of cost and yield figures obtained by one plant or two plants, or any definite number of plants, or all plants operating under this process, or all plants that operated successfully for say more than a year, or does it mean that these figures are the author's estimate of what a plant to be built would probably do? We cannot well discuss the figures themselves until we know what they purport to be. In the one case they are data—in the other they are estimates, unless we are to consider that "data" does not carry the same significance in industrial chemistry that it does in chemistry, in engineering, and in the industries generally.

FRENCH and WITHROW (communicated): We have already stated clearly and concisely, as we thought, what the figures used were, and why they were given. Since Dr. Teeple has said that he agrees in the main with our conclusions, and is simply concerned for the dignity of the word "data," used once or twice in our article, we care little by what name he calls the material which we advanced as in our view adequate to support our opinions regarding this industry. We *are* interested, however, in encouraging any discussion affecting this industry which will bring out the experience of others, without expecting statements as to amounts of wood used, local conditions, etc., as this would indicate at once to one familiar with the industry which particular operation was cited.

It is quite evident from the figures given that difficulty would be had in pointing out "good operating plants" in most of the processes discussed under low market conditions.

CODE OF ETHICS

Prepared in accordance with a vote of the Institute at the Washington Meeting and amended at New York Meeting by Committee on Professional Ethics.

G. W. THOMPSON, Chairman
CHAS. F. McKENNA, A. C. LANGMUIR, A. D. LITTLE

ARTICLE I.

PURPOSE OF THE CODE:

To define the rules of professional conduct and ethics for the members of the Institute.

ARTICLE II.

THE INSTITUTE EXPECTS OF ITS MEMBERS:

1st. That in all their relations, they shall be guided by the highest principles of honor.

2d. The upholding before the public at all times of the dignity of the chemical profession generally and the reputation of the Institute, protecting its members from misrepresentation.

3d. Personal helpfulness and fraternity between its members and toward the profession generally.

4th. The avoidance and discouragement of sensationalism, exaggeration and unwarranted statements. In making the first publication concerning inventions or other chemical advances, they should be made through chemical societies and technical publications.

5th. The refusal to undertake for compensation work which they believe will be unprofitable to clients without first advising said clients as to the improbability of successful results.

6th. The upholding of the principle that unreasonably low charges for professional work tend toward inferior and unreliable

work, especially if such charges are set at a low figure for advertising purposes.

7th. The refusal to lend their names to any questionable enterprise.

8th. Conservatism in all estimates, reports, testimony, etc., especially in connection with the promotion of business enterprises.

9th. That they shall not engage in any occupation which is obviously contrary to law or public welfare.

10th. When a chemical engineer undertakes for others work in connection with which he may make improvements, inventions, plans, designs or other records, he shall preferably enter into a written agreement regarding their ownership. In a case where an agreement is not made or does not cover a point at issue, the following rules shall apply:

a—If a chemical engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, any results in the form of plans, designs or other records shall not be regarded as his property, but the property of his client or employer.

b—If a chemical engineer uses only his own knowledge or information or data, which by prior publication or otherwise are public property, and obtains no chemical engineering data from a client or employer except performance specifications or routine information, then the results in the form of inventions, plans, designs or other records should be regarded as the property of the engineer and the client or employer should be entitled to their use only in the case for which the engineer was retained.

c—All work and results accomplished by the chemical engineer in the form of inventions, plans, designs or other records, or outside of the field for which a client or employer has retained him, should be regarded as the chemical engineer's property.

d—When a chemical engineer participates in the building of apparatus from designs supplied him by a client, the designs remain the property of the client and should not be duplicated by the engineer nor anyone representing him for others without express permission.

e—Chemical engineering data or information which a chemical engineer obtains from his client or employer or which he

creates as a result of such information must be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

f—Designs, data, records and notes made by an employee and referring to his employer's work, should be regarded as his employer's property.

g—A client does not acquire any exclusive right to plans or apparatus made or constructed by a consulting chemical engineer except for the specific case for which they were made.

11th. A chemical engineer cannot honorably accept compensation, financial or otherwise, from more than one interested party, without the consent of all parties; and whether consulting, designing, installing or operating, must not accept compensation directly or indirectly from parties dealing with his client or employer.

When called upon to decide on the use of inventions, apparatus, processes, etc., in which he has a financial interest, he should make his status in the matter clearly understood before engagement.

12th. The chemical engineer should endeavor at all times to give credit for work to those who, so far as his knowledge goes, are the real authors of such work.

13th. Undignified, sensational or misleading advertising is not permitted.

14th. Contracts made by chemical engineers should be subject to the Code of Ethics unless otherwise specified.

ARTICLE III.

For the administration of this Code of Ethics, a Committee on Ethics shall be appointed by the president holding office at the time of the adoption of this Code with the approval of the Council, to consist of five members; one appointed for five years, another for four years, another for three years, another for two years, another for one year, and thereafter, the president then holding office shall appoint one member annually to serve for five years and also fill such vacancies as may occur for an unexpired term. All of these members shall be over forty years of age. The Committee shall elect its own chairman. The Committee on Ethics shall investigate all complaints submitted to them bearing upon the professional con-

duct of any member, and after a fair opportunity to be heard has been given to the member involved, shall report its findings to the Council, whose action shall be final.

ARTICLE IV.

Amendments.

Additions to or modifications of this Code may be made according to Article VIII of the Constitution.

CONSTITUTION

ARTICLE I.

NAME.

This organization shall be termed,

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS

ARTICLE II.

OBJECTS.

The objects of this organization shall be:

To advance the cause of applied chemical science.

To give the profession of Chemical Engineers such standing before the community as will justify its recognition by Municipal, State, and National authorities in public works.

To raise the professional standard among Chemical Engineers, discouraging and prohibiting unprofessional conduct.

To coöperate with educational institutions for the improvement of the education of the men who are to enter this profession.

To encourage original work in chemical technology.

To promote pleasant acquaintance and social and professional intercourse among its members.

To publish and distribute such papers as shall add to classified knowledge in chemical engineering and shall increase industrial activity.

ARTICLE III

MEMBERSHIP

SECTION 1. (*Qualifications for Membership.*) Membership shall consist of two grades: Active and Junior.

ACTIVE MEMBERSHIP shall require the following preparation and training:

All candidates must be not less than 30 years of age and must be proficient in chemistry and in some branch of engineering as applied to chemical problems, and must at the time of election be engaged actively in work involving the application of chemical principles to the arts. All candidates for admission to this Institute are expected to have *expert knowledge of at least one branch of applied chemistry.* and must fulfill one of the following requirements:

1. Candidates who hold no degree from an approved university or technical school must have had ten years' experience in chemical technology; five being in responsible charge of operations requiring the elaboration of raw materials, the design of machinery involving chemical processes, or the application of chemistry to industry.

2. Candidates who hold the degree of A. B. (Bachelor of Arts) from an approved university or technical school offering a four-year course must have had at least eight years of practical experience as outlined under No. 1.

3. Candidates who hold the degree of Ch. E. (Chemical Engineer), B. S. (Bachelor of Science), in Chemistry or Chemical Engineering, or E. E. (Electrical Engineer), C. E. (Civil Engineer), or M. E. (Mechanical Engineer), or equivalent degrees from an approved university or technical school offering at least a four-year course, must have had at least five years' practical experience as outlined under No. 1.

4. For candidates who in addition hold the degree of Ph. D. (Doctor of Philosophy) or Sc. D. (Doctor of Science) in Chemistry, the number of years required to earn the higher degree may be deducted from the number of years of experience required.

JUNIOR MEMBERSHIP shall require the following preparation and training:

All candidates must be not less than 23 years of age and must be engaged, at the time of election, in some branch of applied chemistry and must fulfill one of the following requirements:

1. Hold the degree of Ch.E. (Chemical Engineer), B.S. (Bachelor of Science) in Chemistry or Chemical Engineering, E.E. (Electrical Engineer), C.E. (Civil Engineer), M.E. (Mechanical Engineer), or equivalent degree from an approved university or technical school offering at least a four years' course.

2. Have had five years' experience in Applied Chemistry.

Junior Members shall have all privileges of the Institute excepting those of voting, holding office, and wearing the emblem or badge of Active Membership. A suitable emblem or badge of Junior Membership as adopted by the Institute may be worn by the Junior Members. When qualified, a Junior Member may apply for Active Membership, but must do so before reaching the age of 35, otherwise his membership shall expire.

Section 2. (*Applications.*) All applications for membership must be made to the Secretary in writing, and shall embody a concise

statement with the dates of the candidate's professional training and experience, and shall be in a form and in such detail as may be prescribed by the Membership Committee. The applicant for Active Membership shall give the names of at least five members to whom he is personally known. The applicant for Junior Membership shall give the names of at least five persons to whom he is personally known, two of whom shall preferably be members of the Institute. Each of these shall be requested by the Secretary to certify to the training, experience, professional attainment, and standing of the applicant. On receiving a favorable report from at least three of these references, the applicant shall be eligible to recommendation by the Membership Committee.

Section 3. (*Election of Members.*) At stated periods the Secretary shall mail to the members a ballot containing a list of all applicants who have been recommended by the Membership Committee. This list shall contain a detailed statement of each applicant's career and the names of the members who have vouched for him. All ballots shall be returned to the Secretary not later than three weeks after the date of issue. The ballots shall be canvassed by the Membership Committee, who shall report to the Council, who shall then declare each applicant elected for whom at least ninety-five per cent. of all ballots cast are in the affirmative. Provided, however, that any member voting in the negative may address a confidential letter to the Council, stating his objections to the candidate with evidence for the charges made. If the Council upon investigation considers such objections valid, they may declare an election void. A rejected candidate may make application again any time after one year. Persons elected to membership shall be notified at once by the Secretary. They must then subscribe to the rules of the Institute.

Section 4. (*Honorary Members.*) As the result of unusual ability and public recognition on the part of the industrial world, a person may, upon nomination of the Council and a vote of the Society at large, be made an Honorary Member, but at no time shall this number exceed five.

Section 5. (*Expulsions.*) For abuse or misuse of the privileges of the Institute or conduct unbecoming a member in the opinion of the Council, a two-thirds vote of the Council may expel any member of the Institute.

Section 6. (*Dues.*) The entrance fee for Active Members shall be $15.00; Junior Members shall pay no entrance fee; Annual dues

for active members $15.00, for Junior Members $10.00. Junior Members, on becoming Active Members, shall pay an entrance fee of $15.00 less $1.00 per year for each year of their membership as Junior Members. Provided, however, that no entrance fee shall be exacted until the membership shall reach 200.

Any member may anticipate his dues for life by paying in advance such a sum as would be demanded by any reputable insurance association to yield an annuity equal to the annual dues from the time of the agreement until death. Upon resignation, or expulsion, all money so provided is to become the property of the Institute. Any person joining the Institute after the middle of the fiscal year is required to pay one-half of the dues only for that year. Any person in arrears for three months shall be notified by the Secretary. For non-payment at the expiration of one-half year, a member forfeits the right to vote or to receive the notices of the Association until dues are paid in full. All members are considered as such unless actual resignations are formally presented and accepted with the full payment of dues. On account of extenuating circumstances, dues may be remitted to any member by a two-thirds vote of the Council.

ARTICLE IV.

OFFICERS.

Section 1. The officers of this Society shall be a President, three Vice-Presidents, a Secretary, a Treasurer, an Auditor, and nine Directors. The officers shall be elected at the annual meeting. The President shall serve one year, the Vice-Presidents for three years each, and the Directors for three years each. The Secretary, Treasurer, and Auditor shall be elected for terms of one year each. At the first annual meeting one Vice-President shall be chosen for one year, one for two years, and one for three years. Three Directors shall be chosen for one year, three for two years, and three for three years. Thereafter, officers shall be chosen annually to serve full terms. The President, Ex-Presidents for the two years succeeding the expiration of their term of office as President, Vice-Presidents, Secretary, Treasurer, and Directors shall constitute the Council of the Institute. The President, Vice-Presidents, and Directors cannot be re-elected within the current twelve months from the expiration of term. The duties of office begin immediately after election and notification. An acceptance of office must be in writing addressed to the Secretary. Vacancies occurring in any office shall be filled by a majority vote of the Council for the

unexpired term. The duties of all officers shall be such as usually pertain to their offices or may be delegated to them by the Council or the Institute.

Section 2. (*Election of Officers.*) After the election at which this Constitution is adopted, the election of officers shall be by letter ballot. The Secretary, at least eight (8) weeks prior to each annual meeting, shall send to every member of the Institute a blank nominating ballot upon which the member may make nominations for the officers and Directors to be elected at the coming annual meeting. The nominating ballot is then to be properly signed and transmitted to the Secretary not later than five (5) weeks prior to the annual meeting. It shall then become the duty of the Secretary to prepare and issue an official ballot upon which shall appear the names of all nominations for office or for Directors which shall have appeared upon at least ten (10) nominating ballots. The official ballots shall be mailed not later than three (3) weeks prior to the annual meeting, one to each member, who shall properly signify on it his choice for the various offices and Directors, and transmit it to the Secretary. At the annual meeting the President shall appoint tellers to whom the Secretary shall deliver all the ballots received by him unopened, and who shall count and announce the vote.

ARTICLE V

COUNCIL

The Council shall have supervision and care of all property of the organization, and shall conduct its affairs according to the Constitution and By-Laws. At each annual meeting it shall present a statement of its proceedings during the year. Eight members of the Council called together by notice from the Secretary shall constitute a quorum, provided, however, that three members may be represented by proxy.

ARTICLE VI.

STANDING COMMITTEES.

The Council shall appoint the following committees:

1. FINANCE.
2. COMMITTEE ON MEETINGS.
3. PUBLICATIONS.
4. MEMBERSHIP.
5. LIBRARY.
6 HOUSE COMMITTEE.

FINANCE COMMITTEE.

The Finance Committee shall have charge of the financial affairs of the Institute. This committee must prepare the budget and approve all expenditures. The Chairman of the Committee may be the Auditor of the Institute.

MEMBERSHIP COMMITTEE.

The Membership Committee shall be constituted of fifteen members, ten of whom may vote by proxy at any meeting. To the Membership Committee all applications for membership shall be referred. It is the duty of this committee to see that no person is admitted to the organization who is not qualified.

COMMITTEE ON MEETINGS.

This committee shall have charge of all meetings of the organization and shall fix dates and places of meeting.

COMMITTEE ON PUBLICATIONS.

This committee shall look after the papers presented to the Institute. If considered expedient, any or all of these papers may be published and distributed to members.

LIBRARY COMMITTEE.

This committee shall have charge of all permanent records, books, papers, pamphlets, etc., and shall obtain and place on file a complete record of all patent literature in reference to chemical engineering.

HOUSE COMMITTEE.

This committee shall look after the social affairs of the Institute, fixing the time and place of entertainments.

ARTICLE VII.

MEETINGS.

The annual meeting of the Association shall be held in December, the exact date to be fixed by the Council.

This Institute shall be governed by its Constitution in conformity with the laws of the United States. All questions shall be decided by majority of votes cast. The Institute shall not be held responsible for opinions expressed in papers. The name or use of the Institute shall not be tolerated for any commercial purpose.

Upon the adoption of this Constitution officers shall be elected immediately to hold office until the election and installation of their successors.

ARTICLE VIII.

AMENDMENTS TO THE CONSTITUTION.

Any member may propose an amendment by addressing the Secretary. At the first regular meeting thereafter the subject shall be discussed, and if worthy, notice to vote on same shall be posted until the next regular meeting, and written copy of the notice shall be sent to each member. The proposed amendment shall then be discussed in open meeting and can be passed by two-thirds vote of all members of the Institute as the result of letter ballot.

BY-LAWS

ORDER OF BUSINESS.

REGULAR MEETING.

Reading of minutes of last stated meeting.
Miscellaneous announcements.
Reading of papers, discussion, and communications.
Adjournment.

ANNUAL MEETING.

Reading of minutes of last stated meeting.
Miscellaneous announcements.
Stated business.
Annual reports.
Election of officers.
Address of retiring President, etc.
Adjournment.

In all questions requiring parliamentary ruling not provided for by the Rules of the Institute, "Robert's Rules of Order" shall be the governing authority.

OFFICERS AND COMMITTEES FOR 1914

COUNCIL

Elected at New York Meeting, December 10, 1913

President,

M. C. Whitaker ..... New York, N. Y.

Vice-Presidents,

R. K. Meade ..... Baltimore, Md.
G. W. Thompson ..... Brooklyn, N. Y.
A. C. Langmuir ..... Brooklyn, N. Y.

Secretary,

John C. Olsen ..... New York, N. Y.

Treasurer,

F. W. Frerichs ..... St. Louis, Mo.

Auditor,

H. M. Kaufmann ..... New York, N. Y.

Ex-Presidents,

L. H. Baekeland ..... Yonkers, N. Y.
T. B. Wagner ..... New York, N. Y.

Directors for One Year

A. C. Langmuir ..... Brooklyn, N. Y.
H. S. Miner ..... Gloucester City, N. J.
A. Bement ..... Chicago, Ill.

Directors for Two Years

Geo. D. Rosengarten ..... Philadelphia, Pa.
Jokichi Takamine ..... New York, N. Y.
Jas. R. Withrow ..... Columbus, O.

Directors for Three Years

Henry Howard ..... Boston, Mass.
J. C. Hebden ..... Providence, R. I.
I. P. Lihme ..... Cleveland, O.

Committee on Publications

Olsen, J. C., *Chairman*
Gray, C. W.
Hart, Edward
Bain, J. Watson
Ittner, M. H.
Cushman, A. S.
Miner, H. S.

Membership Committee

Langmuir, A. C., *Chairman*
Adamson, Geo. P.
Bassett, Wm. H.
Converse, W. A.
DeCew, J. A.
Dow, A. W.
Ittner, M. H.
Rosengarten, Geo. D.
Kaufmann, H. M.
Miner, H. S.
Olney, L. A.
Richards, J. W.
Robertson, A.
Thomson, G. W.

Chairmen of Local Committees on Membership

Frerichs, F. W.	St. Louis, Mo.
Belden, A. W.	Pittsburgh, Pa.
Lihme, I. P	Cleveland, O.
Rosengarten, Geo. D	Philadelphia, Pa.
Byers, H. G.	Seattle, Wash.
Parker, T. J	New York, N. Y.
Little, A. D	Boston, Mass.
Converse, W. A.	Chicago, Ill.
Corse, W. M	Buffalo, N. Y.
Haanel, Eugene	Ottawa, Canada.

Committee on Chemical Engineering Education

Withrow, Jas. R., *Chairman*
Sadtler, Samuel P.
Hart, Edward
Little, A. D.
Wagner, T. B.

Committee on Meetings

Ayer, A. W., *Chairman*
Booth, Wm. M.
Langmuir, A. C.
Meade, R. K.
Olsen, J. C.
Sadtler, S. S.
Mason, Wm. P.
Parker, T. J.

Finance Committee

Toch, Maximilian, *Chairman*
Catlin, C. A.
Zinseer, F. G.

Committee on Medal

Booth, Wm. M., *Chairman*
Richards, J. W.
Robertson, A.
Sadtler, Samuel P.

Library Committee

Alexander, Jerome, *Chairman*
Olsen, J. C.
Myers, Ralph, E.

Committee on Patents

Baekeland, L. H., *Chairman*
Grosvenor, Wm. M.
Toch, Maximilian
Lee, Fitzhugh

Committee on Public Policy

McKenna, Chas. F., *Chairman*
Frerichs, F. W.
Baekeland, L. H.
Taylor, Edw. R.
Takamine, Jokichi
Wagner, T. B.

Committee on Catalogues

Grosvenor, W. M., *Chairman*
Thompson, G. W.
Olsen, J. C.
Marsh, C. W.
Wesson, D.

LIST OF MEMBERS, AUGUST, 1914

Honorary Member

CHANDLER, CHAS. F., Columbia University, New York City.

Active Members

ACHESON, EDWARD G., Niagara Falls, N. Y.
President, International Acheson Graphite Co.

ADAMSON, GEORGE P., 233 Reeder St., Easton, Pa.
Vice-President and General Manager, The Baker and Adamson Chemical Co.

ADGATE, MATTHEW, Naugatuck, Conn.
Supt. of the Naugatuck Chemical Co.

ALEXANDER, D. B. W., R. F. D. No. 2, Box 52, Los Angeles, Cal.
Pacific Coast Chemist for The Barber Asphalt Paving Co.

ALEXANDER, JEROME, 502 West 45th St., New York City.
Treasurer and Chemist, National Gum and Mica Co., National Glue and Gelatin Works.

ALLEN, LUCIUS E., Box 22, Belleville, Ont., Can.
Consulting Chemical Engineer; Managing Director Ontario Limestone and Clay Co., Ltd., Belleville, Ont.

ANDERSON, LOUIS J., 315 Burke St., Easton, Pa.
Chemical Engineer, Alpha Portland Cement Co., Easton, Pa.

ANDREWS, LAUNCELOT W., Davenport, Ia.
President, Andrews Chemical Works.

ARNOLD, CHARLES E., 602 West 20th St., Wilmington, Del.

AUSTIN, HERBERT, 485 North Main St., Fall River, Mass.
Chemical Engineer and Partner Manager of Ernest Scott & Co., of Fall River, Mass., and Montreal, P. Q.

AYER, ARTHUR W., 3403 Gray's Ferry Rd., Philadelphia, Pa.
General Supt., Harrison Bros. & Co.

BAEKELAND, LEO H., Yonkers, N. Y.
Research Chemist and Chemical Engineer.

BAIN, J. WATSON, University of Toronto, Toronto, Can.
Associate Professor of Applied Chemistry.

BAIRD, WM. H., 1199 Woodward Ave., Detroit, Mich.
Gen. Mgr., The Garden City Sugar and Land Co., Garden City, Kan.

BAKER, JOHN T., Phillipsburg, N. J. President, J. T. Baker Chemical Co.

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In charge of Laboratory and Dept. Mfg. Glass, Whitall Tatum Co.

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BARTOW, EDWARD, Urbana, Ill.
Professor of Analytical Chemistry, Univ. of Ill.; Director of State Water Survey of Illinois; Consulting Chemist with the Davenport Water Co.

BASKERVILLE, CHAS., 611 W. 110th St., New York, N. Y.
Professor of Chemistry, and Director of the Laboratory, College City of New York; Chemical Inventor.

BASSETT, WILLIAM H., Cheshire, Conn. Metallurgist, American Brass Co.

BEBIE, J., 1800 South 2d St., St. Louis, Mo.
Chemical Engineer, Monsanto Chemical Works.

BECK, ARTHUR G., care Canada Cement Co. Exchaw, Alberta, Canada.

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Chemical Engineer and Consulting Chemist.

BEERS, FRANK T., Washburn, Wis.
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BEHREND, OTTO F., Erie, Pa.
Vice-President and Treasurer, Hammermill Paper Co.

BELDEN, A. W., c/o Jones & Laughlin Steel Co.,
Aliguippa Works, Woodlawn, Pa.

BEMENT, A., 206 S. LaSalle St., Chicago, Ill.
Consulting Mining and Mechanical Engineer.

BERG, HOLGER V., Newport, Del.
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Consulting Chemical Engineer.

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ELDRED, FRANK R., c/o Eli Lilly & Co., Indianapolis, Ind.
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HAANEL, EUGENE, Dept. of Mines, Ottawa, Ont., Can.
Director of Mines, Dept. of Mines, Ottawa, Ont., Can.

HALL, CHAS. M., c/o Aluminum Co. of America, Niagara Falls, N. Y.
First Vice-President of the Aluminum Co. of America.

HART, EDWARD, Easton, Pa.
Prof. Chemistry, Lafayette College; President Baker & Adamson Co.; Prop. Chem. Pub. Co.; Consulting Engineer.

HEBDEN, JOHN C., Box 465, Providence, R. I.
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* Deceased. May 1, 1914.

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HOLLAND, WM. R., Gloucester City, N. J.
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Chief Chemist, Eastern Branch, Corn Products Refining Co.

ITTNER, MARTIN H., Colgate & Co., Jersey City, N. J.
Chief Chemist, Colgate & Co.

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Prof. Chemical Engineering Practice, Carnegie Technical Schools.

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JONES, L. C., Syracuse, N. Y.
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General Manager, Mutual Chemical Co. of America.

KESSLER, JOHN J., 224 S. Vandeventer Ave., St. Louis, Mo.
President and General Mgr. of The Dielectric Mfg. Co., also Chemical Engineer.

KILMER, FREDERICK BARNETT, 147 College Ave., New Brunswick, N. J.
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Chief Technologist, American Cyanamid Co., Niagara Falls, N. Y.

LANGMUIR, ARTHUR C., 9 Van Brunt St., Brooklyn, N. Y.
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LARKIN, E. H., 3600 N. Broadway, St. Louis, Mo.
Director, National Ammonia Co., St. Louis, Mo.

LAZELL, E. W., 426 Railway Exchange Bldg., Portland, Ore.
Edwards & Lazell, Consulting and Chemical Engineers.

LEE, FITZHUGH, Grasselli Chemical Co., Cleveland, Ohio.
Assistant Chairman Manufacturing Committee, Grasselli Chemical Co.

LE MAISTRE, F. J., Ridley Park, Del. Co., Pa.
Chemical Engineer, E. I. du Pont de Nemours Powder Co.

LESSNER, C. B., Carril, Spain.
Manager of the Carril Works and Chemist to the San Finx Tin Mines, Ltd., and Metallurgical Chemist to the Angelita Mines.

LE SUEUR, ERNEST A., 50 McLaren St., Ottawa, Ont., Canada.
General Manager and President of the General Explosives Co., Ltd.

LIHME, IENS P., Grasselli Chemical Co., Cleveland, Ohio.
Engineer, Grasselli Chemical Co.

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Works Chemist, Western Electric Co., Hawthorne Works.

LITTLE, A. D., 93 Broad St., Boston, Mass.
President and General Manager, Arthur D. Little, Inc., Chemists and Engineers; President and General Manager, Chemical Products Co., Boston, Mass.

LOVE, EDWARD G., 130 E. 15th St., New York, N Y.
Chief Chemist, Consolidated Gas Company of New York.

LUNDTEIGEN, A., c/o Ash Grove Lime and Portland Cement Co., Kansas City, Mo.
Managing Engineer, Ash Grove Lime and Portland Cement Co., Kansas City, Mo.

MALLINCKRODT, EDWARD, St. Louis, Mo.
President Mallinckrodt Chemical Works.

MARSH, CLARENCE W., Niagara Falls, N. Y.
Chief Engineer, The Development and Funding Co., New York City.

MASON, WILLIAM P., Troy, N. Y.
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